New Tall Wood Code Provisions: Understanding Advanced Design Topics

Presented by [Presenter's Name]

Credit: Hacker Architects

"The Wood Products Council" is a Registered Provider with The American Institute of Architects Continuing Education Systems (AIA/CES), Provider #G516.

Credit(s) earned on completion of this course will be reported to AIA CES for AIA members. Certificates of Completion for both AIA members and non-AIA members are available upon request.

This course is registered with AIA CES for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product.

Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Course Description

In January 2019, the International Code Council (ICC) approved a set of proposals to allow tall wood buildings as part of the 2021 International Building Code (IBC). Based on these proposals, the 2021 IBC will include three new construction types—Type IV-A, IV-B and IV-C—allowing the use of mass timber or noncombustible materials. These new types are based on the previous Heavy Timber construction type (renamed Type IV-HT) but with additional fire-resistance ratings and levels of required noncombustible protection. This presentation will take a detailed look at the new code provisions and methods of addressing the new requirements. Topics will include tall-wood specific high rise and sprinkler requirements, methods of demonstrating fire-resistance ratings, fire design for penetrations, connections and abutting panels, allowances for exposed timber, exterior walls, concealed spaces and more.

Learning Objectives

1. Explore the three new tall wood construction types and discuss related code provisions such as allowable heights and fire-resistance ratings.

2. Discuss code-compliant options for exposing mass timber, where up to 2-hour fire-resistance ratings are required, and demonstrate design methodologies for achieving these ratings.

3. Review code requirements unique to tall wood buildings, focusing on items such as sprinklers, shaft construction and concealed spaces.

4. Highlight design options for addressing topics such as fire stops at penetrations through mass timber assemblies and exterior walls fire-resistance in tall timber structures.

NEW CONSTRUCTION TYPES IN 2021 IBC

Type IV-A – Maximum 18 stories, with gypsum wallboard on all mass timber.

Type IV-B – Maximum 12 stories, limited-area of exposed mass timber walls and ceilings allowed.

Type IV-C – Maximum 9 stories, all exposed mass timber designed for a 2-hour fire resistance.

Credit: American Wood Council

New Building Types

18 STORIES
BUILDING HEIGHT 270'
ALLOWABLE BUILDING AREA 972,000 SF
AVERAGE AREA PER STORY 54,000SF

TYPE IV-A

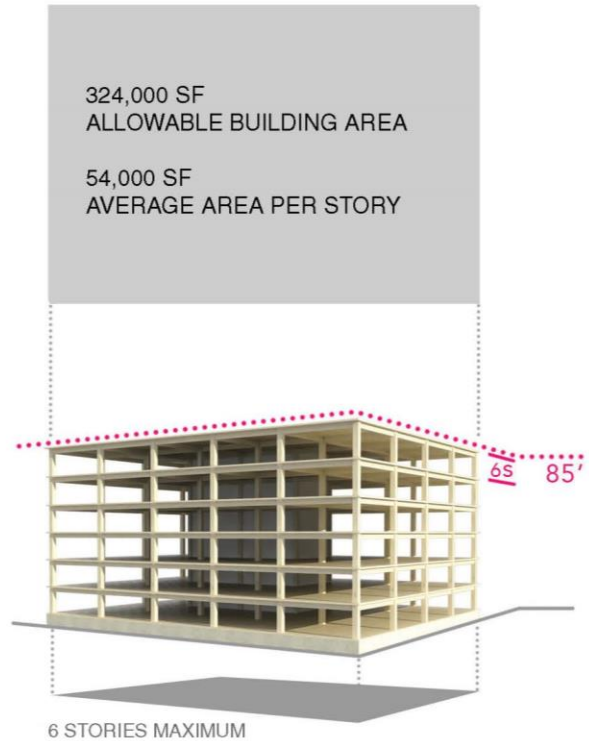
12 STORIES
BUILDING HEIGHT 180 FT
ALLOWABLE BUILDING AREA 648,000 SF
AVERAGE AREA PER STORY 54,000SF

TYPE IV-B

9 STORIES
BUILDING HEIGHT 85'
ALLOWABLE BUILDING AREA 405,000 SF
AVERAGE AREA PER STORY 45,000 SF

TYPE IV-C

IBC 2021



6 STORIES MAXIMUM
85'-0" MAXIMUM BUILDING HEIGHT
324,00 SF MAXIMUM AREA

TYPE IV- HT

IBC 2015

BUSINESS OCCUPANCY [GROUP B]

*BUILDING FLOOR-TO-FLOOR HEIGHTS ARE SHOWN AT 12'-0" FOR ALL EXAMPLES FOR CLARITY IN COMPARISON BETWEEN 2015 TO 2021 IBC CODES.

Credit: Susan Jones, atelierjones

Tall Wood Building Size Limits

	Construction Type (All Sprinklered Values)						
	I-A	I-B	**IV-A**	**IV-B**	**IV-C**	IV-HT	III-A
Occupancies	**Allowable Building Height above Grade Plane, Feet (IBC Table 504.3)**						
A, B, R	Unlimited	180	**270**	**180**	**85**	85	85
	Allowable Number of Stories above Grade Plane (IBC Table 505.4)						
A-2, A-3, A-4	Unlimited	12	**18**	**12**	**6**	4	4
B	Unlimited	12	**18**	**12**	**9**	6	6
R-2	Unlimited	12	**18**	**12**	**8**	5	5
	Allowable Area Factor (At) for SM, Feet^2 (IBC Table 506.2)						
A-2, A-3, A-4	Unlimited	Unlimited	**135,000**	**90,000**	**56,250**	45,000	42,000
B	Unlimited	Unlimited	**324,000**	**216,000**	**135,000**	108,000	85,500
R-2	Unlimited	Unlimited	**184,500**	**123,000**	**76,875**	61,500	72,000

Tall Wood Building Size Limits

	Construction Type (Unsprinklered Values)					
	I-A	I-B	IV-A	IV-B	IV-C	IV-HT
Occupancies	**Allowable Building Height above Grade Plane, Feet (IBC Table 504.3)**					
A, B, R	Unlimited	160	**65**	**65**	**65**	**65**
	Allowable Number of Stories above Grade Plane (IBC Table 505.4)					
A-2, A-3, A-4	Unlimited	11	**3**	**3**	**3**	**3**
B	Unlimited	11	**5**	**5**	**5**	**5**
R-2	Unlimited	11	**4**	**4**	**4**	**4**
	Allowable Area Factor (At) for SM, Feet^2 (IBC Table 506.2)					
A-2, A-3, A-4	Unlimited	Unlimited	**45,000**	**30,000**	**18,750**	**15,000**
B	Unlimited	Unlimited	**108,000**	**72,000**	**45,000**	**36,000**
R-2	Unlimited	Unlimited	**61,500**	**41,000**	**25,625**	**20,500**

Even so, Sprinklers may be required by 903.2 (all occupancies) and definitely for residential (420.4)

Tall Wood Building Size Limits

	Construction Type (Unsprinklered Values)					
	I-A	I-B	IV-A	IV-B	IV-C	IV-HT
Occupancies	**Allowable Building Height above Grade Plane, Feet (IBC Table 504.3)**					
A, B, R	Unlimited	160	65	65	65	65
	Allowable Number of Stories above Grade Plane (IBC Table 505.4)					
A-2, A-3, A-4	Unlimited	11	3	3	3	3
B	Unlimited	11	5	5	5	5
R-2	Unlimited	11	4	4	4	4
	Allowable Area Factor (At) for SM, Feet^2 (IBC Table 506.2)					
A-2, A-3, A-4	Unlimited	Unlimited	45,000	30,000	18,750	15,000
B	Unlimited	Unlimited	108,000	72,000	45,000	36,000
R-2	Unlimited	Unlimited	61,500	41,000	25,625	20,500

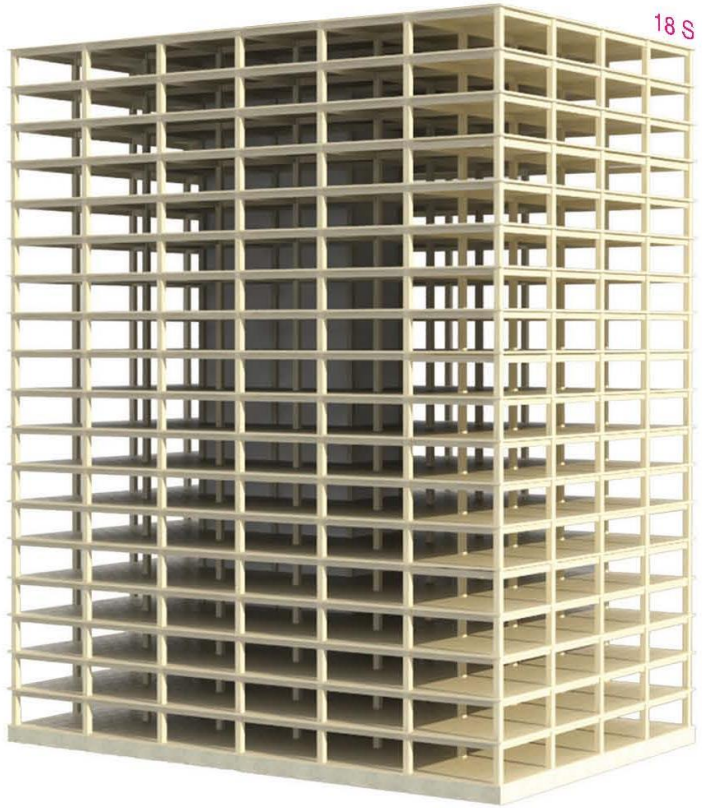
In almost all cases, sprinklers will be required

Even so, Sprinklers may be required by 903.2 (all occupancies) and definitely for residential (420.4)

Non-Tall Opportunities – Large Area

	Construction Type (All Sprinklered Values)						
	I-A	I-B	**IV-A**	**IV-B**	**IV-C**	IV-HT	III-A
Occupancies	**Allowable Building Height above Grade Plane, Feet (IBC Table 504.3)**						
A, B, R	Unlimited	180	**270**	**180**	**85**	85	85
	Allowable Number of Stories above Grade Plane (IBC Table 505.4)						
A-2, A-3, A-4	Unlimited	12	**18**	**12**	**6**	4	4
B	Unlimited	12	**18**	**12**	**9**	6	6
R-2	Unlimited	12	**18**	**12**	**8**	5	5
	Allowable Area Factor (At) for SM, Feet^2 (IBC Table 506.2)						
A-2, A-3, A-4	Unlimited	Unlimited	**135,000**	**90,000**	**56,250**	45,000	42,000
B	Unlimited	Unlimited	**324,000**	**216,000**	**135,000**	108,000	85,500
R-2	Unlimited	Unlimited	**184,500**	**123,000**	**76,875**	61,500	72,000

Type IV-A



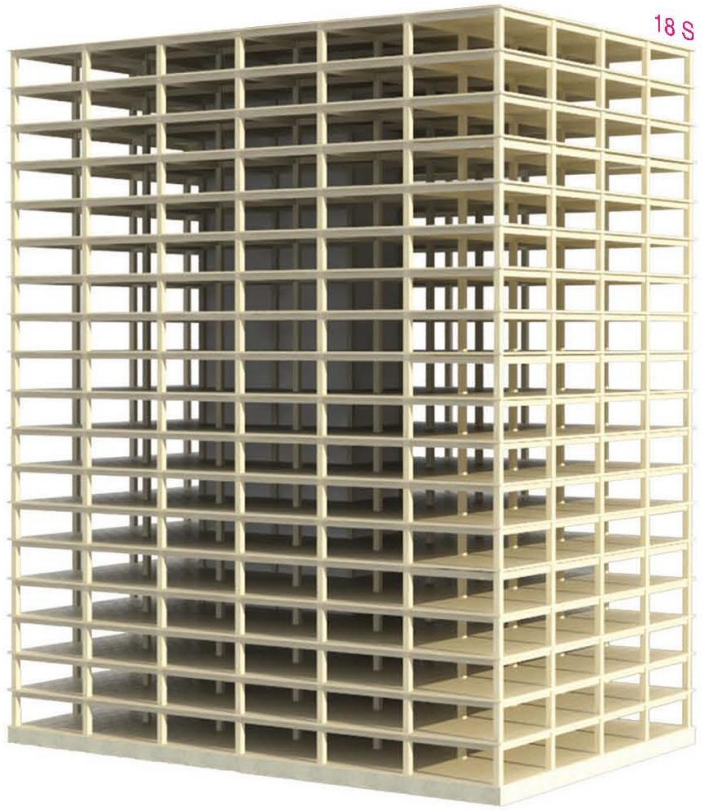
18 STORIES	
BUILDING HEIGHT	270’
ALLOWABLE BUILDING AREA	972,000 SF
AVERAGE AREA PER STORY	54,000SF

TYPE IV-A

Credit: Susan Jones, atelierjones

Photos: Structurlam, naturally:wood, Fast + Epp

Type IV-A Height and Area Limits



18 STORIES
BUILDING HEIGHT 270'
ALLOWABLE BUILDING AREA 972,000 SF
AVERAGE AREA PER STORY 54,000SF

TYPE IV-A

Credit: Susan Jones, atelierjones

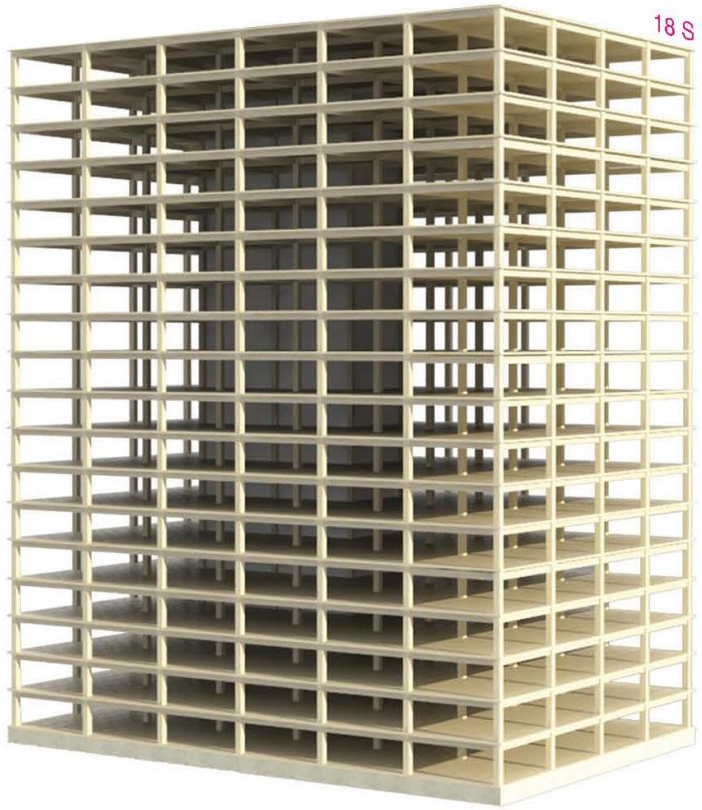
Occupancy	# of Stories	Height	Area per Story	Building Area
A-2	18	270 ft	135,000 SF	405,000 SF
B	18	270 ft	324,000 SF	972,000 SF
M	12	270 ft	184,500 SF	553,500 SF
R-2	18	270 ft	184,500 SF	553,500 SF

Areas exclude potential frontage increase

In most cases, Type IV-A height & story allowances = 1.5 * Type I-B height & story allowances

Type IV-A area = 3 * Type IV-HT area

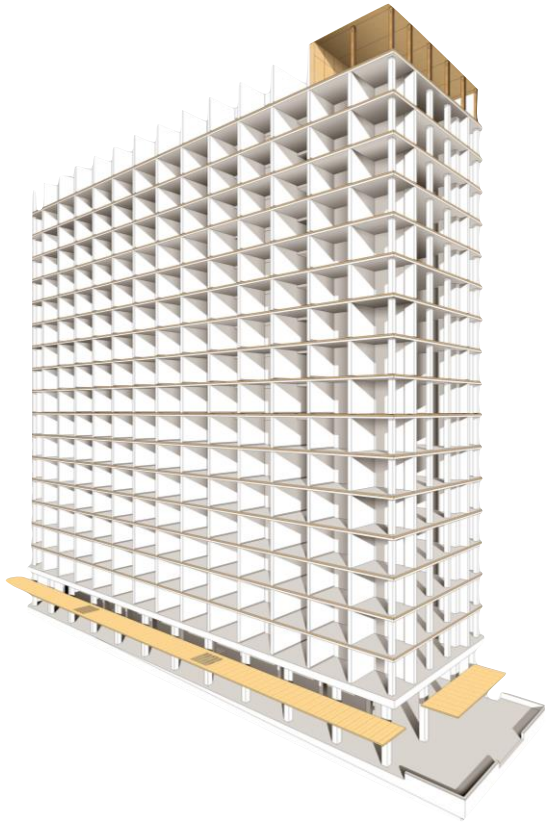
Type IV-A Protection vs. Exposed

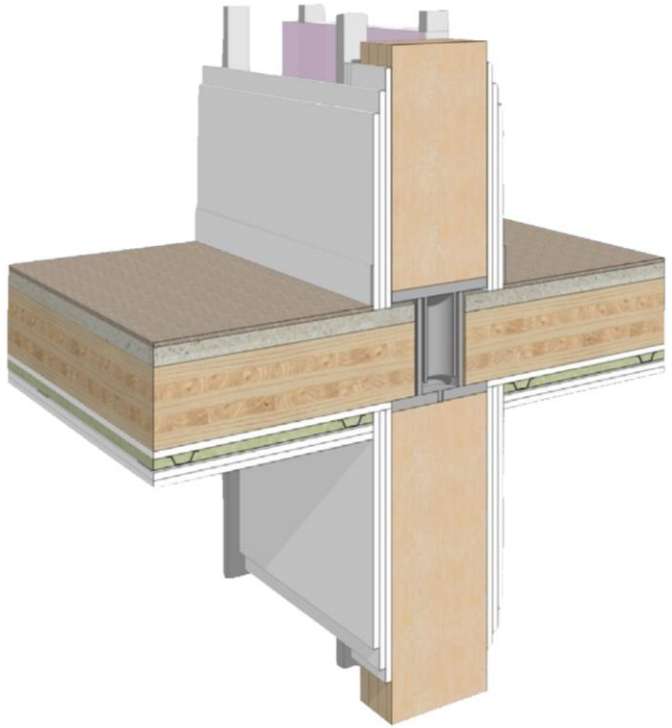


18 STORIES
BUILDING HEIGHT 270'
ALLOWABLE BUILDING AREA 972,000 SF
AVERAGE AREA PER STORY 54,000SF

TYPE IV-A

Credit: Susan Jones, atelierjones





Credit: Acton Ostry Architects, Fast + Epp

100% NC protection on all surfaces of Mass Timber

Type IV-A Fire Resistance Ratings (FRR)

IV-A

Primary Frame FRR	3 HR (2 HR at Roof)
Ext or Int Bearing Wall FRR	3 HR
Floor Construction FRR	2 HR
Roof Construction FRR	1.5 HR

Type IV-A Fire Resistance Ratings (FRR)

IV-A

	FRR	Min. NC Protection
Primary Frame FRR	3 HR (2 HR at Roof)	120 min (80 min at Roof)
Ext or Int Bearing Wall FRR	3 HR	120 min
Floor Construction FRR	2 HR	80 min
Roof Construction FRR	1.5 HR	80 min

½" Type X Gypsum = 25 min | 5/8" Type X Gypsum = 40 min


Credit: Urban One

Noncombustible Protection (NC)

TABLE 722.7.1(a)
PROTECTION REQUIRED FROM NONCOMBUSTIBLE COVERING MATERIAL

Required Fire Resistance Rating of Building Element per Tables 601 and 602 (hours)	Minimum Protection Required from Noncombustible Protection (minutes)	
1	40	1 layer 5/8 Type X
2	80	2 layers 5/8 Type X
3 or more	120	3 layers 5/8 Type X

TABLE 722.7.1(b)
PROTECTION PROVIDED BY NONCOMBUSTIBLE COVERING MATERIAL

Noncombustible Protection	Protection Contribution (minutes)
1/2 inch Type X Gypsum Board	25
5/8 inch Type X Gypsum Board	40

Noncombustible Protection (NC)

The definition of “Noncombustible Protection (For Mass Timber)” is created to address the passive fire protection of mass timber.

Mass timber is permitted to have its own fire-resistance rating (e.g., Mass Timber only) or have a fire resistance rating based on the fire resistance through a combination of the mass timber fire-resistance plus protection by non-combustible materials as defined in Section 703.5 (e.g., additional materials that delay the combustion of mass timber, such as gypsum board).


Credit: Urban One

MT Fire Resistance Ratings (FRR)

IBC 722.7
The fire resistance rating of the mass timber elements shall consist of the fire resistance of the unprotected element (MT) added to the protection time of the noncombustible (NC) protection.

+

= **FRR**

MT Fire Resistance Ratings (FRR)

However, FRR Doesn't always need to be from a combination of MT + NC. In some cases, just NC can be used, in other cases, just MT can be used:

IBC 602.4
Mass timber elements shall meet the fire resistance rating requirements of this section based on either the fire resistance rating of the noncombustible protection, the mass timber, or a combination of both.

MT Type IV Minimum Sizes

In addition to meeting FRR, all MT elements must also meet minimum sizes

These minimum sizes have been in place for old type IV (current type IV-HT) construction and the same minimums sizes also apply to MT used in new types IV-A, IV-B and IV-C

Contained in IBC 2304.11

Type IV Minimum Sizes - Framing

Framing		Solid Sawn (nominal)	Glulam (actual)	SCL (actual)
Floor	Columns	8 x 8	$6^{3}/_{4}$ x 8¼	7 x 7½
	Beams	6 x 10	5 x 10½	5¼ x 9½
Roof	Columns	6 x 8	5 x 8¼	5¼ x 7½
	Beams*	4 x 6	3 X $6^{7}/_{8}$	3½ X 5½

Minimum Width by Depth in Inches
See IBC 2018 2304.11 or IBC 2015 602.4 for Details

*3” nominal width allowed where sprinklered


Photo: WoodWorks

Type IV Minimum Sizes – Floor/Roof Panels

Floor Panels/Decking:

- 4” thick CLT (actual thickness)
- 4” NLT/DLT/GLT (nominal thickness)
- 3” thick (nominal) decking covered with: 1” decking or 15/32” WSP or ½” particleboard

Roof Panels/Decking:

- 3” thick CLT (nominal thickness)
- 3” NLT/DLT/GLT (nominal thickness)
- 2” decking (nominal thickness)
- 1-1/8” WSP


Photo: StructureCraft


Photos: Aitor Sanchez/ Ewing Cole


Photo: LEVER Architecture

MT Type IV Minimum Sizes – Walls

Exterior Walls for Type IV-A B C

- CLT or Non-combustible

Exterior Walls for Type IV-HT

- CLT or FRTW or Non-combustible
- IBC 2018 - 6” Thick Wall (FRTW or CLT)
- IBC 2021 - 4” Thick CLT

MT Type IV Minimum Sizes – Walls

MT Interior Walls in all Type IV:

- Laminated construction 4” thick
- Solid wood construction min. 2 layers of 1” matched boards

Other Interior Walls in Type IV A,B,C

- Non-combustible (0 hr for nonbearing)

Other Interior Walls in Type IV HT

- Non-combustible (1 hr min)
- Wood stud wall (1 hr min)

Verify other code requirements for FRR (eg. interior bearing wall; occupancy separation)

Type IV-A Fire Resistance Ratings (FRR)

IV-A

FRR Examples:

Primary Structural Frame (Beam, Column, Bearing Wall):

3 HR Required

NC protection = at least 120 min

- **Use 3 layers of 5/8” type X Gypsum = 120 min (2 HR)**
  Mass Timber FRR req’d = 3 HR – 2 HR = 1 HR


Credit: StructureCraft


Credit: Urban One

Type IV-A Fire Resistance Ratings (FRR)

IV-A

FRR Examples:

Floor Panels:

2 HR Required

NC Protection = at least 80 min

- **Use 2 layers of 5/8” type X Gypsum = 80 min (1.33 HR), plus:**
  - **Mass Timber FRR req’d = 2 HR – 1.33 HR = 0.67 HR, or**
- **Use 3 layers of 5/8” Type X Gypsum = 120 min (2 HR) and no FRR from MT req’d**

Credit: Urban One

Type IV-A Protection

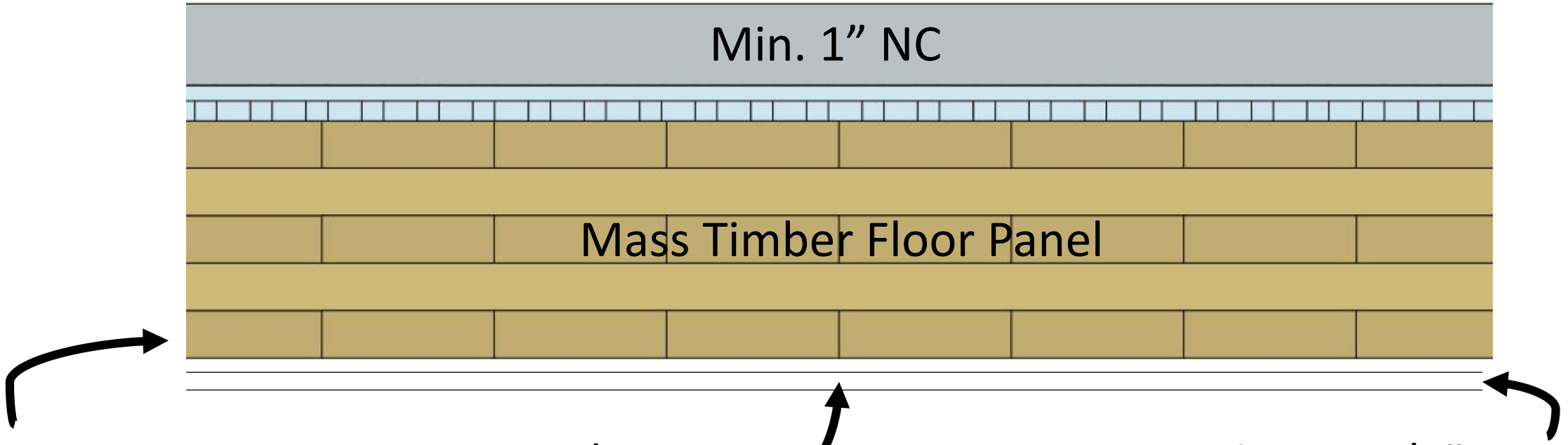
IV-A

Floor Surface Protection	Min. 1 inch of NC protection
Roof Construction Protection	Min. 2 layers 5/8” type X gyp on inside face
Ext Wall Protection	Min. 1 layer 5/8” type X gyp on outside face Min. 2 layers 5/8” type X gyp on inside face (non-brng) Min. 3 layers 5/8” type X gyp on inside face (brng)

Type IV-A Fire Resistance Ratings (FRR)

IV-A

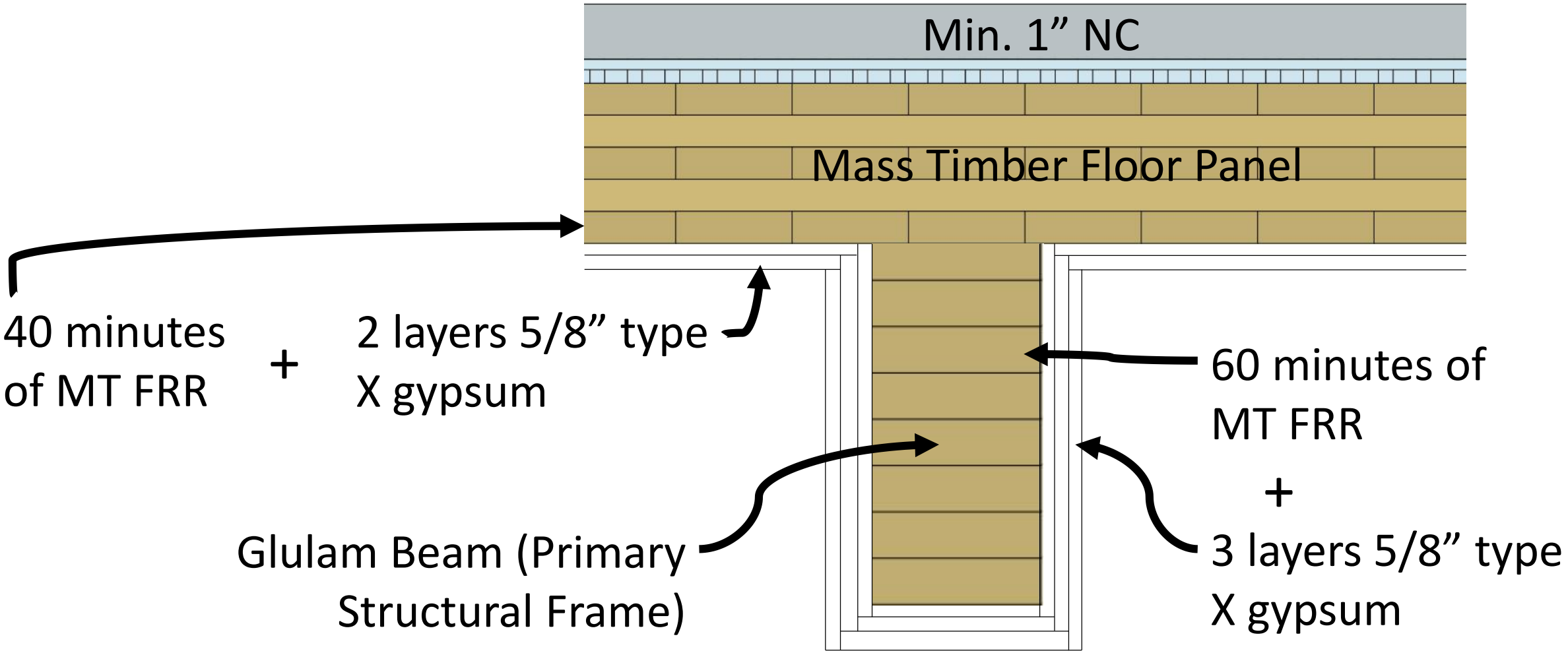
FRR & NC Floor Panel Example: 2 HR



Type IV-A Fire Resistance Ratings (FRR)

IV-A

Primary Frame (3 HR) + Floor Panel Example (2 HR):

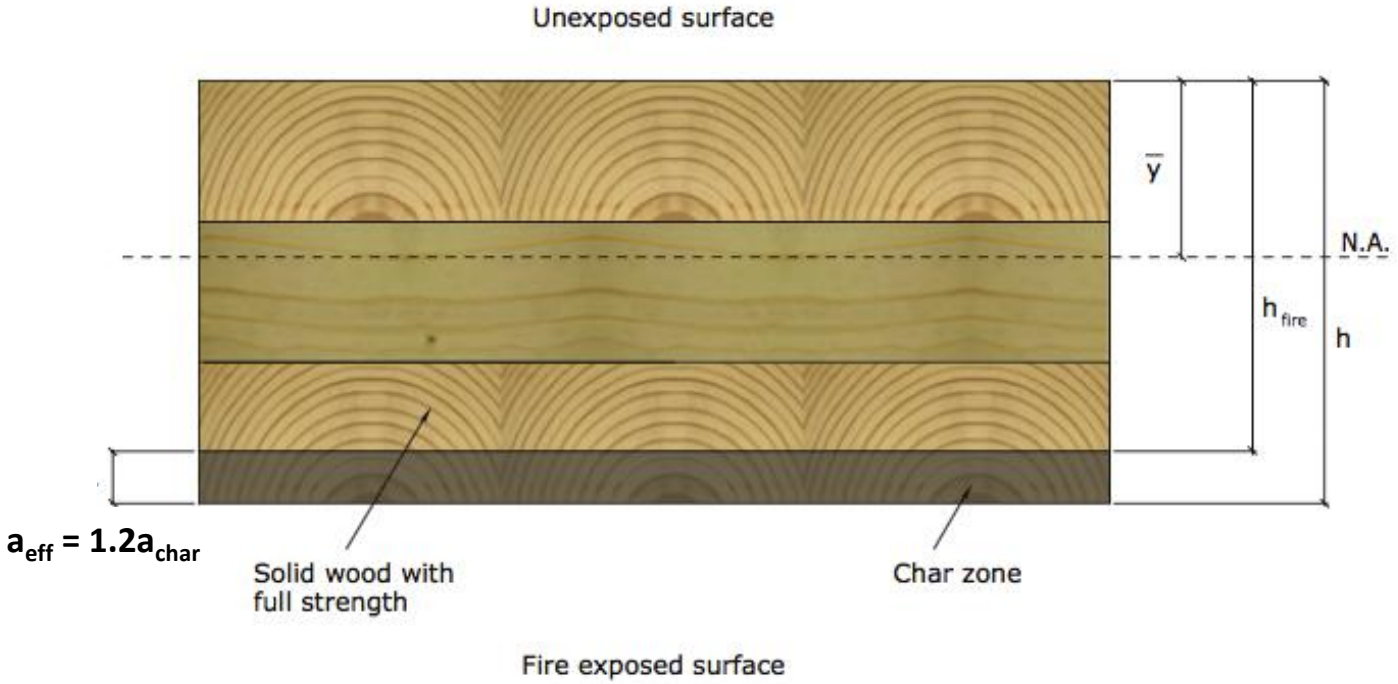


MT Fire Resistance Ratings (FRR)

How do you determine FRR of MT?

2 Options:

1. **Calculations in Accordance with IBC 722 → NDS Chapter 16**
2. **Tests in Accordance with ASTM E119**



MT Fire Resistance Ratings (FRR)

MT FRR Calculations Method:

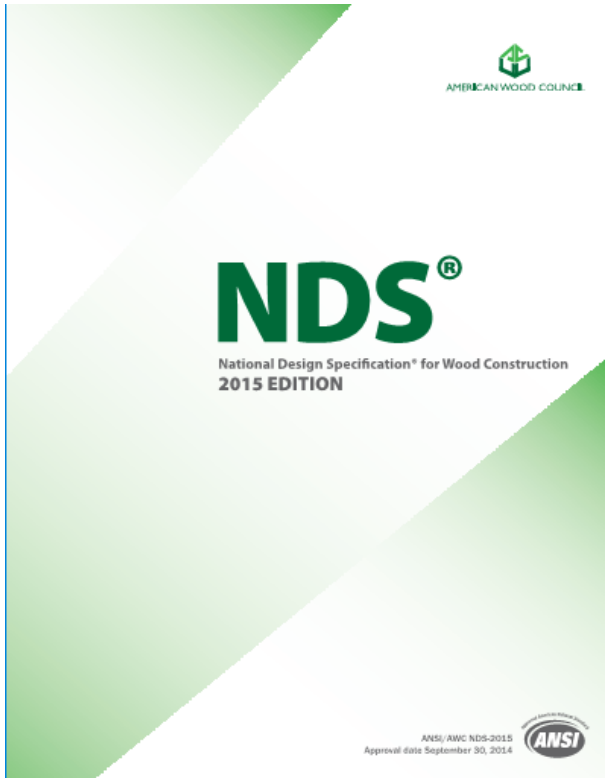
- **IBC 703.3 allows several methods of determining FRR. One is calculations per 722.**
- **722.1 refers to NDS Chpt 16 for exposed wood FRR**

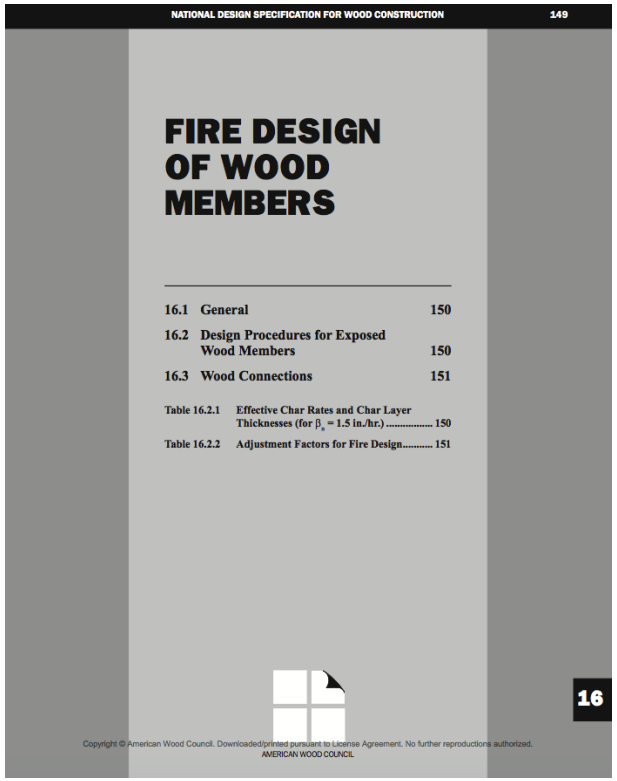
703.3 Methods for determining fire resistance. The application of any of the methods listed in this section shall be based on the fire exposure and acceptance criteria specified in ASTM E119 or UL 263. The required *fire resistance* of a building element, component or assembly shall be permitted to be established by any of the following methods or procedures:

3. Calculations in accordance with Section 722.

722.1 General. The provisions of this section contain procedures by which the *fire resistance* of specific materials or combinations of materials is established by calculations. These procedures apply only to the information contained in this section and shall not be otherwise used. The calculated *fire resistance* of concrete, concrete masonry and clay masonry assemblies shall be permitted in accordance with ACI 216.1/TMS 0216. The calculated *fire resistance* of steel assemblies shall be permitted in accordance with Chapter 5 of ASCE 29. The calculated *fire resistance* of exposed wood members and wood decking shall be permitted in accordance with Chapter 16 of ANSI/AF&PA *National Design Specification for Wood Construction (NDS)*.

MT Fire Resistance Ratings (FRR)






Credit: FPInnovations

NDS Chapter 16 includes calculation of fire resistance of NLT, CLT, Glulam, Solid Sawn and SCL wood products

Table 16.2.1B Effective Char Depths (for CLT with β_n=1.5in./hr.)

Required Fire Endurance (hr.)	Effective Char Depths, a_{char} (in.) lamination thicknesses, h_{lam} (in.)								
	5/8	3/4	7/8	1	1-1/4	1-3/8	1-1/2	1-3/4	2
1-Hour	2.2	2.2	2.1	2.0	2.0	1.9	1.8	1.8	1.8
1½-Hour	3.4	3.2	3.1	3.0	2.9	2.8	2.8	2.8	2.6
2-Hour	4.4	4.3	4.1	4.0	3.9	3.8	3.6	3.6	3.6

MT Fire Resistance Ratings (FRR)

Nominal char rate of 1.5”/HR is recognized in NDS. Effective char depth calculated to account for duration, structural reduction in heat-affected zone

Table 16.2.1A Char Depth and Effective Char Depth (for β_n = 1.5 in./hr.)

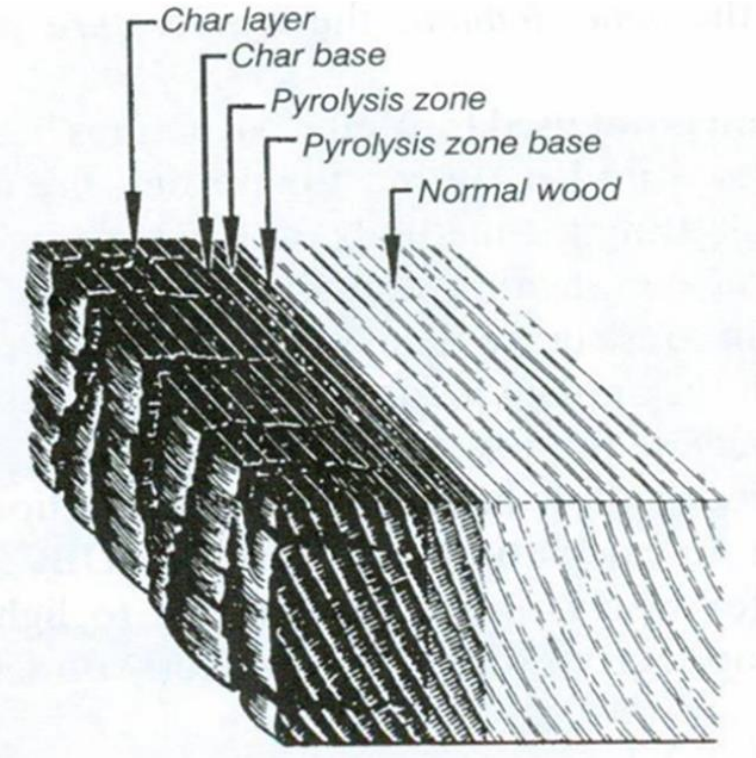
Required Fire Resistance (hr.)	Char Depth, a_{char} (in.)	Effective Char Depth, a_{eff} (in.)
1-Hour	1.5	1.8
1½-Hour	2.1	2.5
2-Hour	2.6	3.2

Table 16.2.1B Effective Char Depths (for CLT with β_n=1.5in./hr.)

Required Fire Endurance (hr.)	Effective Char Depths, a_{char} (in.) lamination thicknesses, h_{lam} (in.)								
	5/8	3/4	7/8	1	1-1/4	1-3/8	1-1/2	1-3/4	2
1-Hour	2.2	2.2	2.1	2.0	2.0	1.9	1.8	1.8	1.8
1½-Hour	3.4	3.2	3.1	3.0	2.9	2.8	2.8	2.8	2.6
2-Hour	4.4	4.3	4.1	4.0	3.9	3.8	3.6	3.6	3.6

MT Fire Resistance Ratings (FRR)

Structural capacity check performed on remaining section, with stress increases



Credit: Forest Products Laboratory

Table 16.2.2 Adjustment Factors for Fire Design[1]

			ASD					
			Design Stress to Member Strength Factor	Size Factor[2]	Volume Factor[2]	Flat Use Factor[2]	Beam Stability Factor[3]	Column Stability Factor[3]
Bending Strength	F_b	x	2.85	C_F	C_V	C_{fu}	C_L	-
Beam Buckling Strength	F_{bE}	x	2.03	-	-	-	-	-
Tensile Strength	F_t	x	2.85	C_F	-	-	-	-
Compressive Strength	F_c	x	2.58	C_F	-	-	-	C_P
Column Buckling Strength	F_{cE}	x	2.03	-	-	-	-	-

$$a_{char} = \beta_t t^{0.813}$$ **Solid Sawn, Glulam, SCL**

$$a_{char} = n_{lam} h_{lam} + \beta_t \left(t - \left(n_{lam} t_{gj}\right)\right)^{0.813}$$ **CLT**

$$a_{eff} = 1.2 a_{char}$$ **Effective Char Depth**

MT Fire Resistance Ratings (FRR)

Tested Assemblies Method:

- **Many successful Mass Timber ASTM E119 fire tests have been completed by industry & manufacturers**

NGC Testing Services

Fire Testing Laboratory

ACCREDITED Testing Laboratory TL-216

TEST REPORT

Page 1 of 53

for

American Wood Council

222 Catoctin Circle SE, Suite 201
Leesburg, VA 20175

Standard Methods of
Fire Tests of Building Construction and Materials
ASTM E 119 – 11a

Test Report No: WP-1950

Assignment No: K-1089

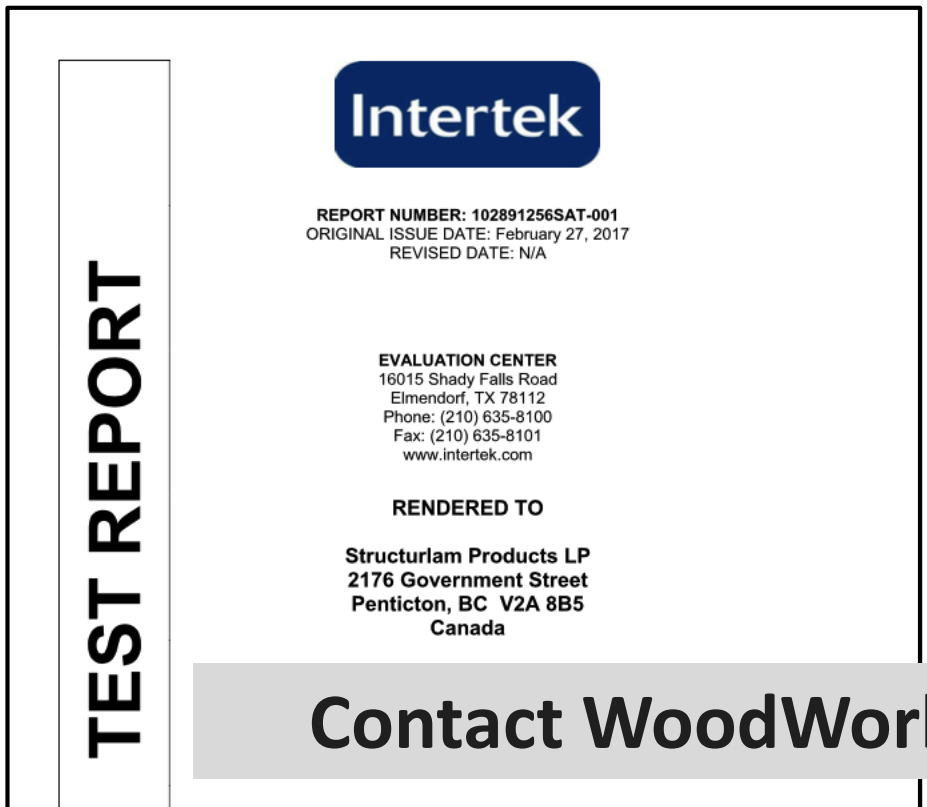
Subject Material: Cross-Laminated Timber and Gypsum Board Wall Assembly (Load-Bearing)

Test Date: October 4, 2012

Report Date: October 15, 2012

Prepared by:
Michael J. Rizzo
Test Engineer

Reviewed by:
Robert J. Menchetti
Director, Laboratory Facilities and Testing Services



TEST REPORT

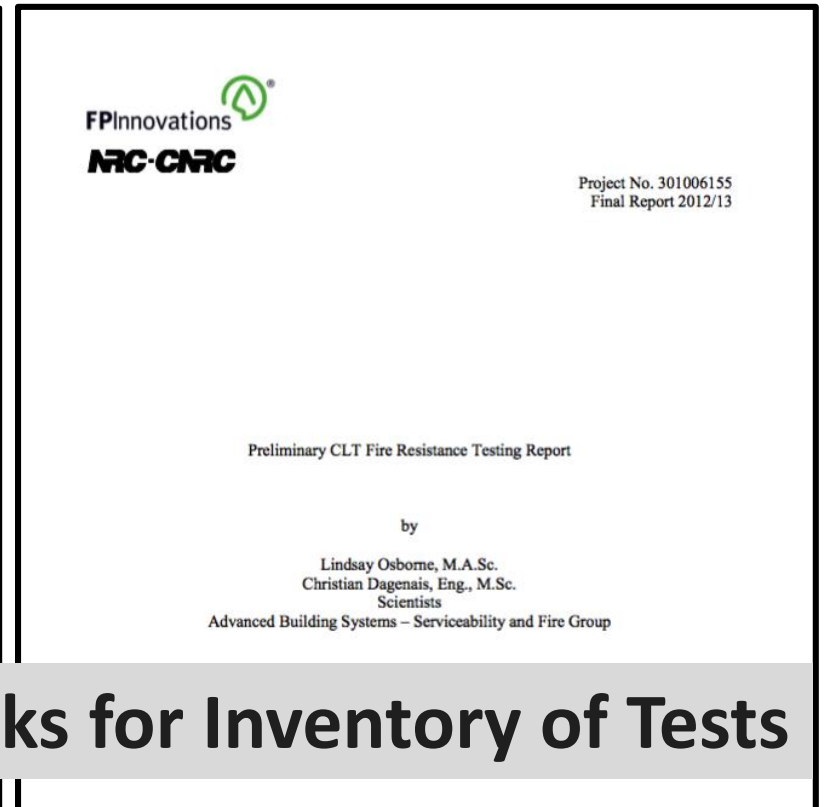
Intertek

REPORT NUMBER: 102891256SAT-001
ORIGINAL ISSUE DATE: February 27, 2017
REVISED DATE: N/A

EVALUATION CENTER
16015 Shady Falls Road
Elmendorf, TX 78112
Phone: (210) 635-8100
Fax: (210) 635-8101
www.intertek.com

RENDERED TO

Structurlam Products LP
2176 Government Street
Penticton, BC V2A 8B5
Canada



FPInnovations
NRC·CNRC

Project No. 301006155
Final Report 2012/13

Preliminary CLT Fire Resistance Testing Report

by

Lindsay Osborne, M.A.Sc.
Christian Dagenais, Eng., M.Sc.
Scientists
Advanced Building Systems – Serviceability and Fire Group

Contact WoodWorks for Inventory of Tests

MT Fire Resistance Ratings (FRR)

WoodWorks™
WOOD PRODUCTS COUNCIL

Fire-Resistive Design of Mass Timber Members

Code Applications, Construction Types and Fire Ratings

Richard McLain, PE, SE • Senior Technical Director • WoodWorks
Scott Breneman, PhD, PE, SE • Senior Technical Director • WoodWorks

For many years, exposed heavy timber framing elements have been permitted in U.S. buildings due to their inherent fire-resistance properties. The predictability of wood's char rate has been well-established for decades and has long been recognized in building codes and standards.

Today, one of the exciting trends in building design is the growing use of mass timber—i.e., large solid wood panel products such as cross-laminated timber (CLT) and nail-laminated timber (NLT)—for floor, wall and roof construction. Like heavy timber, mass timber products have inherent fire resistance that allows them to be left exposed and still achieve a fire-resistance rating. Because of their strength and dimensional stability, these products also offer a low-carbon alternative to steel, concrete, and masonry for many applications. It is this combination of exposed structure and strength that developers and designers across the country are leveraging to create innovative designs with a warm yet modern aesthetic, often for projects that go beyond traditional norms of wood design.

This paper has been written to support architects and engineers exploring the use of mass timber for commercial and multi-family construction. It focuses on how to meet fire-resistance requirements in the International Building Code (IBC), including calculation and testing-based methods. Unless otherwise noted, references refer to the 2018 IBC.

Mass Timber & Construction Type

Before demonstrating fire-resistance ratings of exposed mass timber elements, it's important to understand under what circumstances the code currently allows the use of mass timber in commercial and multi-family construction.

A building's assigned construction type is the main indicator of where and when all wood systems can be used. IBC Section 602 defines five main options (Type I through V) with all but Type IV having subcategories A and B. Types III and V permit the use of wood framing throughout much of the structure and both are used extensively for modern mass timber buildings.

Type III (IBC 602.3) – Timber elements can be used in floors, roofs and interior walls. Fire-retardant-treated wood (FRTW) framing is permitted in exterior walls with a fire-resistance rating of 2 hours or less.

Type V (IBC 602.5) – Timber elements can be used throughout the structure, including floors, roofs and both interior and exterior walls.

Type IV (IBC 602.4) – Commonly referred to as 'Heavy Timber' construction, this option

Carbon12 | Portland, Oregon
Kaiser Group | Path Architecture
Munzing Structural Engineering

Mass Timber Fire Design Resource

- Code compliance options for demonstrating FRR
- Updated as new tests are completed
- Free download at woodworks.org

MT Fire Resistance Ratings (FRR)

Inventory of Fire Tested MT Assemblies

Table 1: North American Fire Resistance Tests of Mass Timber Floor / Roof Assemblies

WoodWorks™ WOOD PRODUCTS COUNCIL

CLT Panel	Manufacturer	CLT Grade or Major x Minor Grade	Ceiling Protection	Panel Connection in Test	Floor Topping	Load Rating	Fire Resistance Achieved (Hours)	Source	Testing Lab
3-ply CLT (114mm 4.488 in)	Nordic	SPF 1650 Fb 1.5E MSR x SPF #3	2 layers 1/2" Type X gypsum	Half-Lap	None	Reduced 36% Moment Capacity	1	1 (Test 1)	NRC Fire Laboratory
3-ply CLT (105mm 4.133 in)	Structurlam	SPF #1/#2 x SPF #1/#2	1 layer 5/8" Type X gypsum	Half-Lap	None	Reduced 75% Moment Capacity	1	1 (Test 5)	NRC Fire Laboratory
5-ply CLT (175mm 6.875")	Nordic	E1	None	Topside Spline	2 staggered layers of 1/2" cement boards	Loaded, See Manufacturer	2	2	NRC Fire Laboratory March 2016
5-ply CLT (175mm 6.875")	Nordic	E1	1 layer of 5/8" Type X gypsum under Z-channels and furring strips with 3 5/8" fiberglass batts	Topside Spline	2 staggered layers of 1/2" cement boards	Loaded, See Manufacturer	2	5	NRC Fire Laboratory Nov 2014
5-ply CLT (175mm 6.875")	Nordic	E1	None	Topside Spline	3/4 in. proprietary gypcrete over Maxxon acoustical mat	Reduced 50% Moment Capactiy	1.5	3	UL
5-ply CLT (175mm 6.875")	Nordic	E1	1 layer 5/8" normal gypsum	Topside Spline	3/4 in. proprietary gypcrete over Maxxon acoustical mat or proprietary sound board	Reduced 50% Moment Capactiy	2	4	UL
5-ply CLT (175mm 6.875")	Nordic	E1	1 layer 5/8" Type X Gyp under Resilient Channel under 7 7/8" I-Joists with 3 1/2" Mineral Wool beween Joists	Half-Lap	None	Loaded, See Manufacturer	2	21	Intertek 8/24/2012
5-ply CLT (175mm 6.875")	Structurlam	E1 M5 MSR 2100 x SPF #2	None	Topside Spline	1-1/2" Maxxon Cyp-Grete 2000 over Maxxon Reinforcing Mesh	Loaded, See Manufacturer	2.5	6	Intertek, 2/22/2016
5-ply CLT (175mm 6.875")	DR Johnson	V1	None	Half-Lap & Topside Spline	2" gypsum topping	Loaded, See Manufacturer	2	7	SwRI (May 2016)
5-ply CLT (175mm 6.875")	Nordic	SPF 1950 Fb MSR x SPF #3	None	Half-Lap	None	Reduced 59% Moment Capacity	1.5	1 (Test 3)	NRC Fire Laboratory
5-ply CLT (175mm 6.875")	Structurlam	SPF #1/#2 x SPF #1/#2	1 layer 5/8" Type X gypsum	Half-Lap	None	Unreduced 101% Moment Capacity	2	1 (Test 6)	NRC Fire Laboratory
7-ply CLT (245mm 9.65")	Structurlam	SPF #1/#2 x SPF #1/#2	None	Half-Lap	None	Unreduced 101% Moment Capacity	2.5	1 (Test 7)	NRC Fire Laboratory
5-ply CLT (175mm 6.875")	SmartLam	SL-V4	None	Half-Lap	nominal 1/2" plywood with 8d nails.	Loaded, See Manufacturer	2	12 (Test 4)	Western Fire Center 10/26/2016
5-ply CLT (175mm 6.875")	SmartLam	V1	None	Half-Lap	nominal 1/2" plywood with 8d nails.	Loaded, See Manufacturer	2	12 (Test 5)	Western Fire Center 10/28/2016
5-ply CLT (175mm 6.875")	DR Johnson	V1	None	Half-Lap	nominal 1/2" plywood with 8d nails.	Loaded, See Manufacturer	2	12 (Test 6)	Western Fire Center 11/01/2016
5-ply CLT (160mm 6.3")	KLH	CV3M1	None	Half-Lap & Topside spline	None	Loaded, See Manufacturer	1	18	SwRI

Materials Permitted

602.4 Type IV. Type IV construction is that type of construction in which the building elements are mass timber or noncombustible materials and have fire resistance ratings in accordance with Table 601. Mass timber elements shall meet the fire resistance rating requirements of this section based on either the fire resistance rating of the noncombustible protection, the mass timber, or a combination of both and shall be determined in accordance with Section 703.2 or 703.3. The minimum dimensions and permitted materials for building elements shall comply with the provisions of this section and Section 2304.11. Mass timber

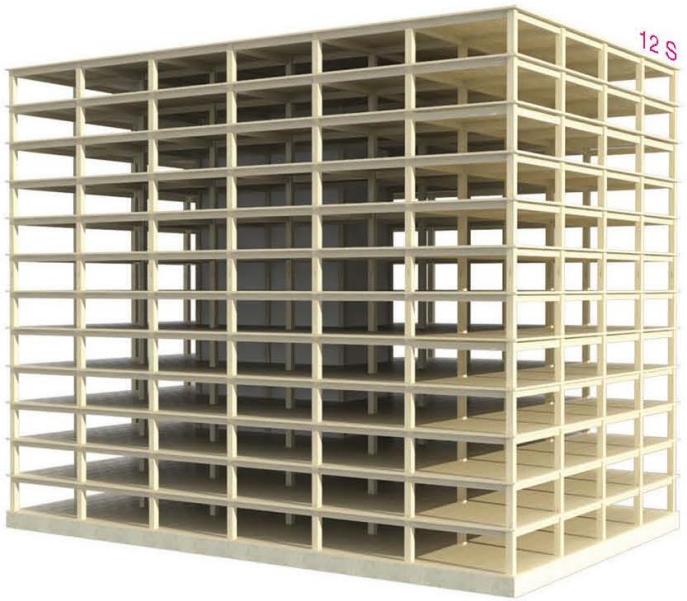
Exterior load-bearing walls and nonload-bearing walls shall be mass timber construction, or shall be of noncombustible construction.

Exception: Type IV-HT Construction in accordance with Section 602.4.4.

The interior building elements, including nonload-bearing walls and partitions, shall be of mass timber construction or of noncombustible construction.

Exception: Type IV-HT Construction in accordance with Section 602.4.4..

Type IV-B



12 STORIES
BUILDING HEIGHT 180 FT
ALLOWABLE BUILDING AREA 648,000 SF
AVERAGE AREA PER STORY 54,000SF

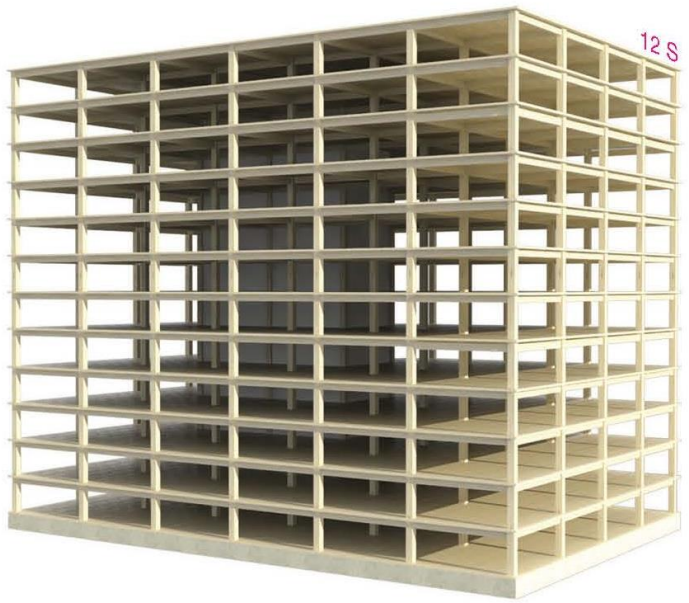
TYPE IV-B

Credit: Susan Jones, atelierjones

Credit: LEVER Architecture

Type IV-B Height and Area Limits

IV-B



12 STORIES
BUILDING HEIGHT 180 FT
ALLOWABLE BUILDING AREA 648,000 SF
AVERAGE AREA PER STORY 54,000SF

TYPE IV-B

Credit: Susan Jones, atelierjones

Occupancy	# of Stories	Height	Area per Story	Building Area
A-2	12	180 ft	90,000 SF	270,000 SF
B	12	180 ft	216,000 SF	648,000 SF
M	8	180 ft	123,000 SF	369,000 SF
R-2	12	180 ft	123,000 SF	369,000 SF

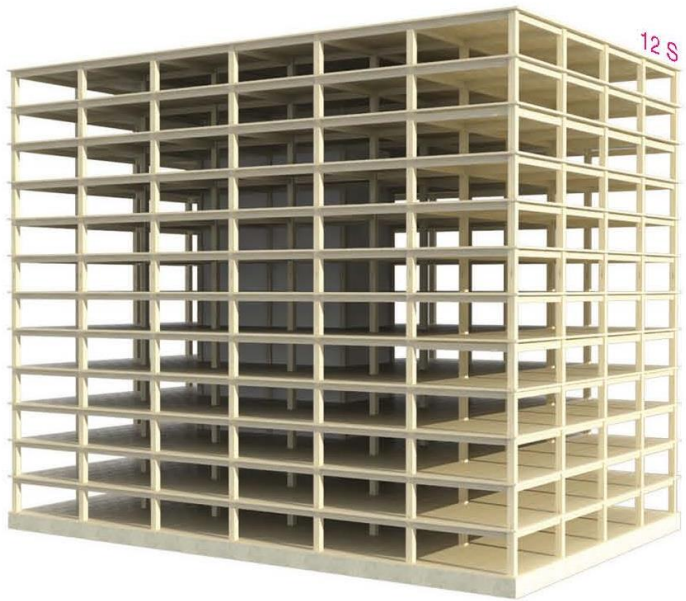
Areas exclude potential frontage increase

In most cases, Type IV-B height & story allowances = Type I-B height & story allowances

Type IV-B area = 2 * Type IV-HT area

Type IV-B Protection vs. Exposed

IV-B



12 STORIES
BUILDING HEIGHT 180 FT
ALLOWABLE BUILDING AREA 648,000 SF
AVERAGE AREA PER STORY 54,000SF

TYPE IV-B

Credit: Susan Jones, atelierjones

Credit: Kaiser+Path

NC protection on all surfaces of Mass Timber except limited exposed areas

~20% of Ceiling or ~40% of Wall can be exposed

Type IV-B Fire Resistance Ratings (FRR)

IV-B

Primary Frame FRR	2 HR (1 HR at Roof)
Ext or Int Bearing Wall FRR	2 HR
Floor Construction FRR	2 HR
Roof Construction FRR	1 HR

Type IV-B Fire Resistance Ratings (FRR)

IV-B

*Applicable to most locations. Limited exposed MT permitted

	FRR	Min. NC Protection
Primary Frame FRR	2 HR (1 HR at Roof)	80 min* (40 min* at Roof)
Ext or Int Bearing Wall FRR	2 HR	80 min*
Floor Construction FRR	2 HR	80 min*
Roof Construction FRR	1 HR	40 min*

½" Type X Gypsum = 25 min | 5/8" Type X Gypsum = 40 min

Credit: Urban One

Type IV-B Protection

IV-B

Floor Surface Protection	Min. 1 inch of NC protection
Roof Construction Protection	Min. 1 layer 5/8” type X gyp on inside face*
Ext Wall Protection	Min. 1 layer 5/8” type X gyp on outside face Min. 2 layers 5/8” type X gyp on inside face*

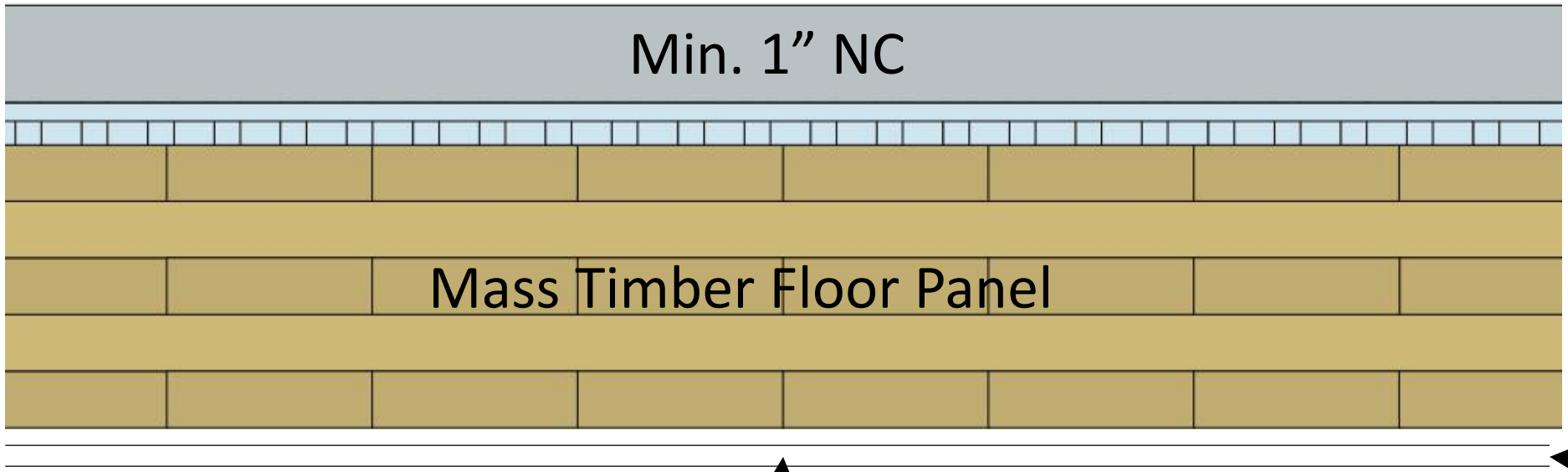
***Applicable to most locations**
Limited exposed MT permitted


Credit: Maxxon

Type IV-B Fire Resistance Ratings (FRR)

IV-B

FRR & NC Floor Panel Example: 2 HR



40 minutes of MT FRR* + 2 layers 5/8” type X gypsum*

OR

3 layers 5/8” type X gypsum*

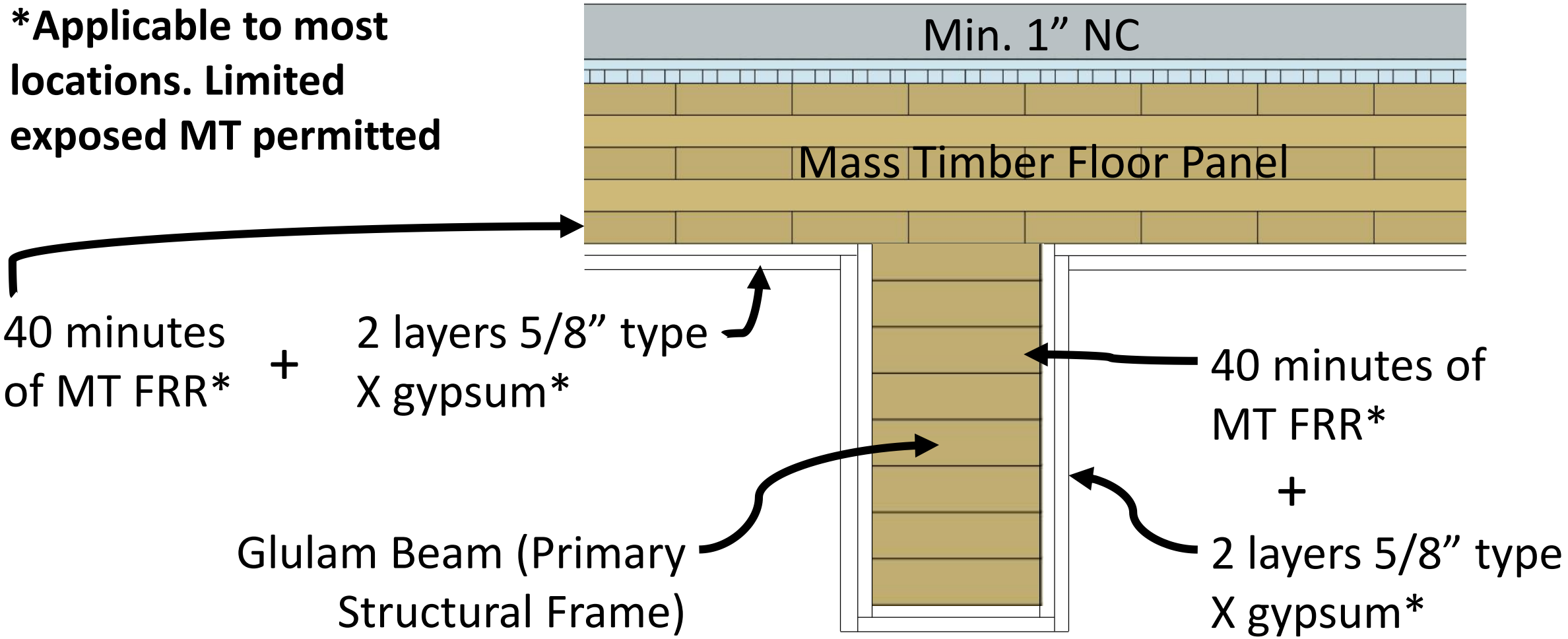
***Applicable to most locations. Limited exposed MT permitted**

Type IV-B Fire Resistance Ratings (FRR)

IV-B

Primary Frame (2 HR) + Floor Panel Example (2 HR):

***Applicable to most locations. Limited exposed MT permitted**



Type IV-B Protection vs. Exposed

IV-B

Limited Exposed MT allowed in Type IV-B for:

- **MT beams and columns which are not integral part of walls or ceilings, no area limitation applies**
- **MT ceilings and beams up to 20% of floor area in dwelling unit or fire area, or**
- **MT walls and columns up to 40% of floor area in dwelling unit or fire area, or**
- **Combination of ceilings/beams and walls/columns, calculated as follows:**

Credit: Kaiser+Path

Type IV-B Protection vs. Exposed

IV-B

Mixed unprotected areas, exposing both ceilings and walls:

- **In each dwelling unit or fire area, max. unprotected area =**

$$(U_{tc}/U_{ac}) + (U_{tw}/U_{aw}) \leq 1.0$$

- **U_{tc} = Total unprotected MT ceiling areas**
- **U_{ac} = Allowable unprotected MT ceiling areas**
- **U_{tw} = Total unprotected MT wall areas**
- **U_{aw} = Allowable unprotected MT wall areas**

Credit: Kaiser+Path

Type IV-B Protection vs. Exposed

IV-B

Design Example: Mixing unprotected MT walls & ceilings

Credit: AWC

800 SF dwelling unit

- U_{ac} = (800 SF)*(0.20) = 160 SF
- U_{aw} = (800 SF)*(0.40) = 320 SF
- Could expose 160 SF of MT ceiling, OR 320 SF of MT Wall, OR
- If desire to expose 100 SF of MT ceiling in Living Room, determine max. area of MT walls that can be exposed

Type IV-B Protection vs. Exposed

IV-B

Design Example: Mixing unprotected MT walls & ceilings

Credit: AWC

$(U_{tc}/U_{ac}) + (U_{tw}/U_{aw}) \leq 1.0$

$(100/160) + (U_{tw}/320) \leq 1.0$

$U_{tw} = 120$ SF

- Can expose 120 SF of MT walls in dwelling unit in combination with exposing 100 SF of MT ceiling

Type IV-B Protection vs. Exposed

IV-B

Horizontal separation of unprotected areas:

- Unprotected portions of mass timber walls and ceilings shall be not less than 15 feet from unprotected portions of other walls and ceilings, measured horizontally along the ceiling and from other unprotected portions of walls measured horizontally along the floor.

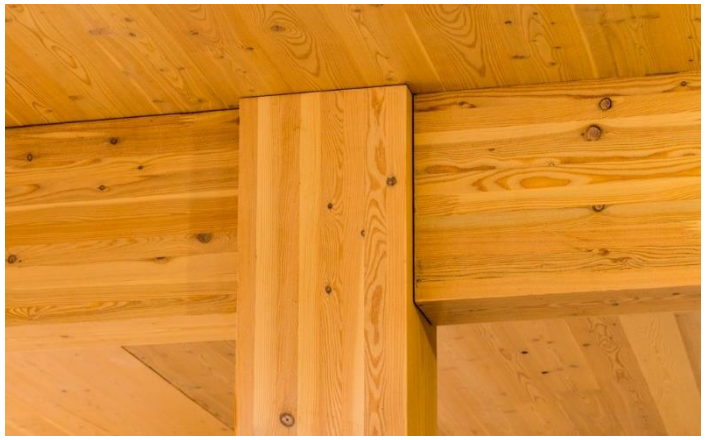
Credit: Kaiser+Path

Type IV-C

9 STORIES	
BUILDING HEIGHT	85’
ALLOWABLE BUILDING AREA	405,000 SF
AVERAGE AREA PER STORY	45,000 SF

TYPE IV-C

Credit: Susan Jones, atelierjones



Photos: Baumberger Studio/PATH Architecture/Marcus Kauffman

Type IV-C Height and Area Limits

IV-C

9 STORIES
BUILDING HEIGHT 85'
ALLOWABLE BUILDING AREA 405,000 SF
AVERAGE AREA PER STORY 45,000 SF

TYPE IV-C

Credit: Susan Jones, atelierjones

Occupancy	# of Stories	Height	Area per Story	Building Area
A-2	6	85 ft	56,250 SF	168,750 SF
B	9	85 ft	135,000 SF	405,000 SF
M	6	85 ft	76,875 SF	230,625 SF
R-2	8	85 ft	76,875 SF	230,625 SF

Areas exclude potential frontage increase

In most cases, Type IV-C height allowances = Type IV-HT height allowances, but add'l stories permitted due to enhanced FRR

Type IV-C area = 1.25 * Type IV-HT area

Type IV-C Protection vs. Exposed

IV-C

9 STORIES	
BUILDING HEIGHT	85’
ALLOWABLE BUILDING AREA	405,000 SF
AVERAGE AREA PER STORY	45,000 SF

TYPE IV-C

Credit: Susan Jones, atelierjones

Credit: Kaiser+Path, Ema Peter

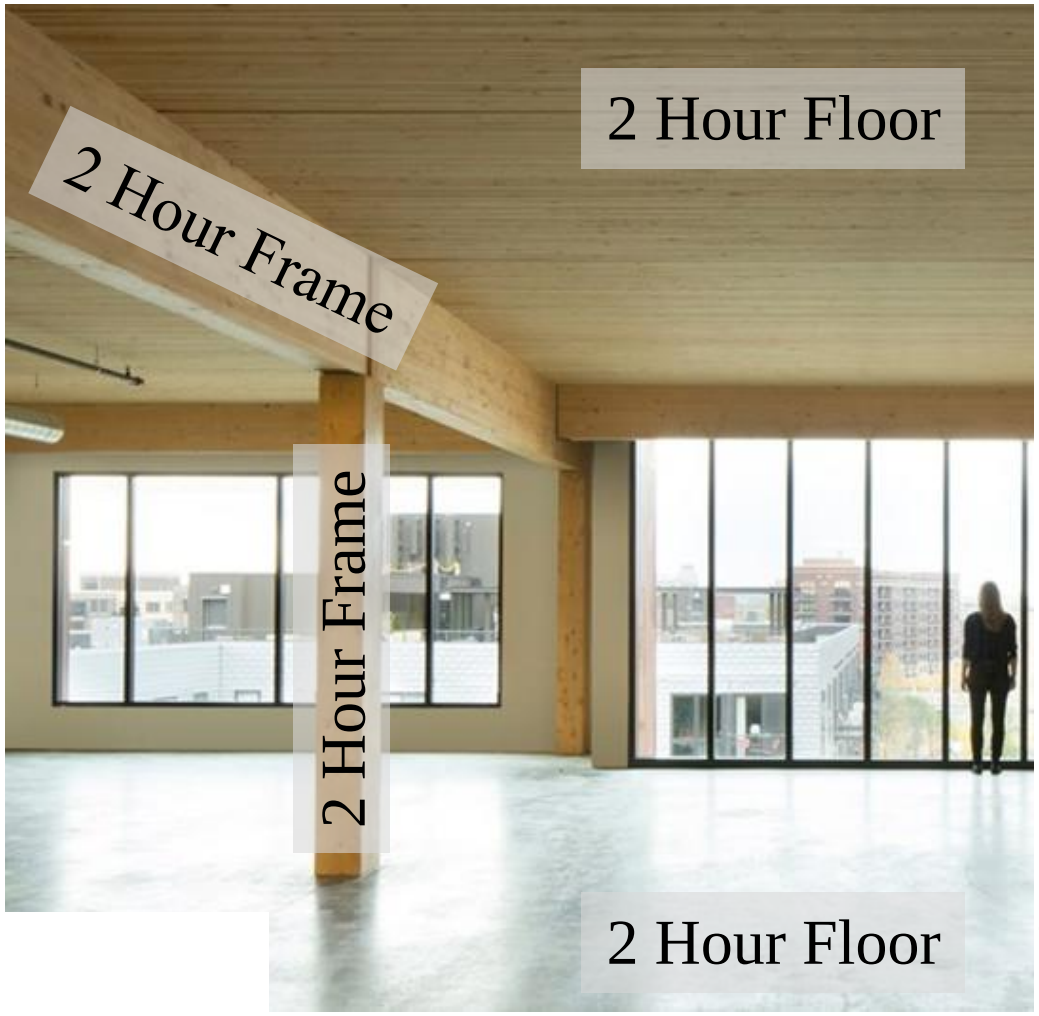
All Mass Timber surfaces may be exposed

Exceptions: Shafts, concealed spaces, outside face of exterior walls

Type IV-C Fire Resistance Ratings (FRR)

IV-C

Primary Frame FRR	2 HR (1 HR at Roof)
Ext or Int Bearing Wall FRR	2 HR
Floor Construction FRR	2 HR
Roof Construction FRR	1 HR



Credit: Ema Peter

Same FRR as IV-B, but all MT in IV-C may be

Type IV-C Protection

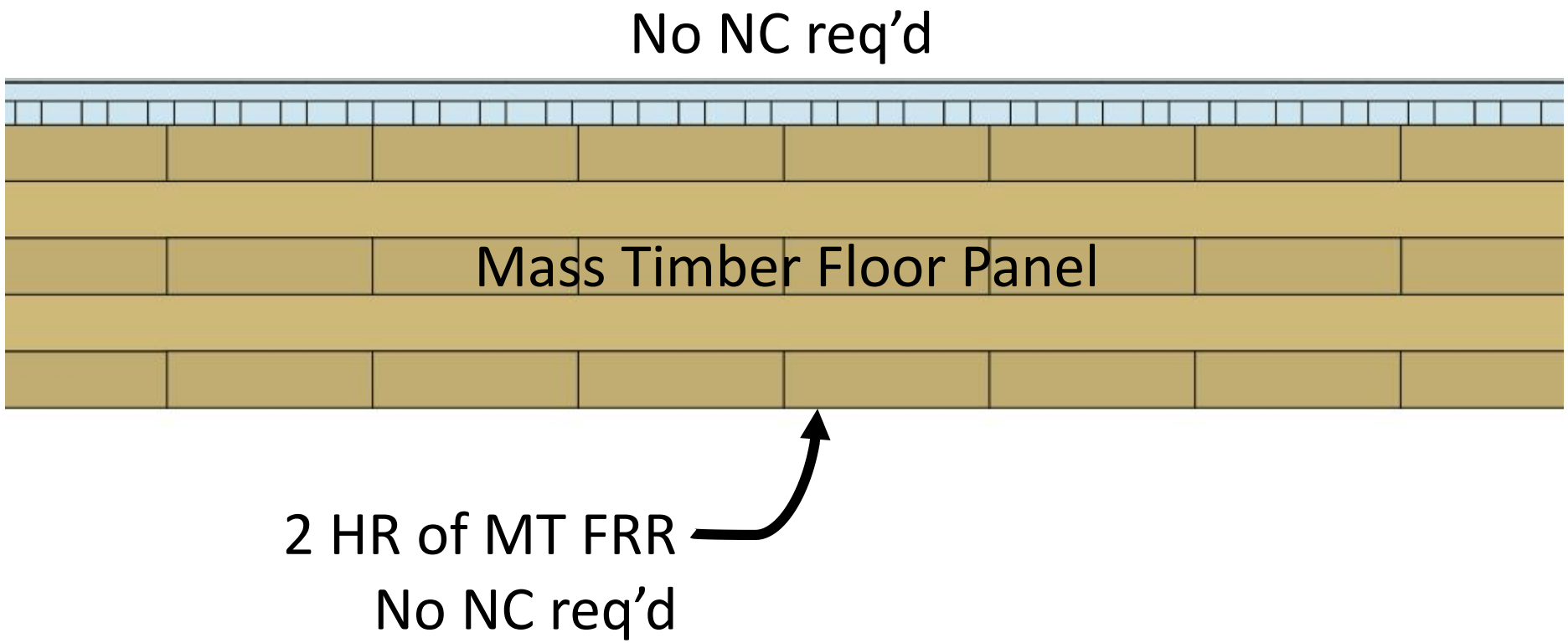
IV-C

Floor Surface Protection	None req'd
Roof Construction Protection	None req'd
Ext Wall Protection	Min. 1 layer 5/8" type X gyp on outside face None req'd on inside face

Type IV-C Fire Resistance Ratings (FRR)

IV-C

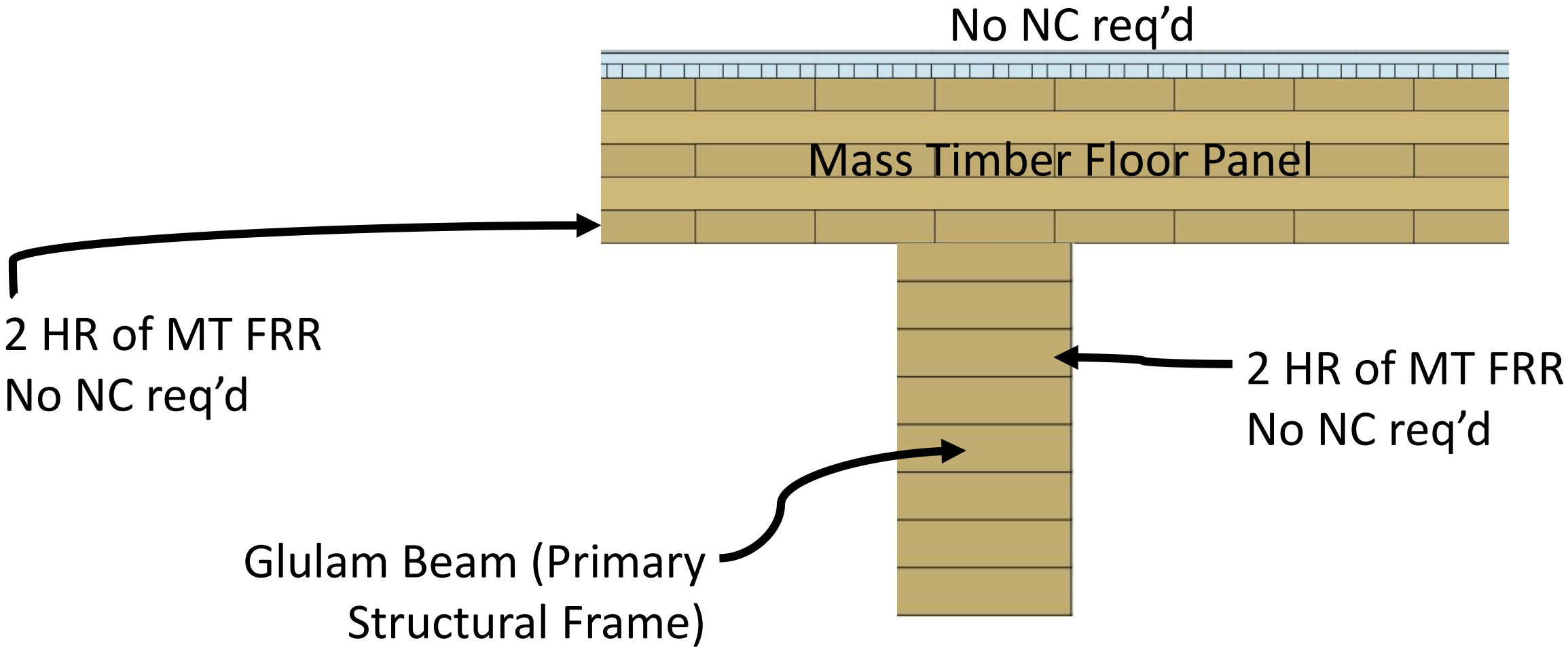
FRR & NC Floor Panel Example: 2 HR



Type IV-C Fire Resistance Ratings (FRR)

IV-C

Primary Frame (2 HR) + Floor Panel Example (2 HR):



Fire Resistance Ratings (FRR) Recap

	IV-A	IV-B	IV-C	IV-HT
Roof Construction	1.5	1	1	HT
Primary Frame @ Roof	2	1	1	HT
Floor Construction	2	2	2	HT
Primary Frame	3	2	2	HT
Exterior Bearing Walls	3	2	2	2
Interior Bearing Walls	3	2	2	1 or HT

Required Fire Resistance Rating in Hours (per Table 601 only)

Noncombustible Protection (NC) Recap

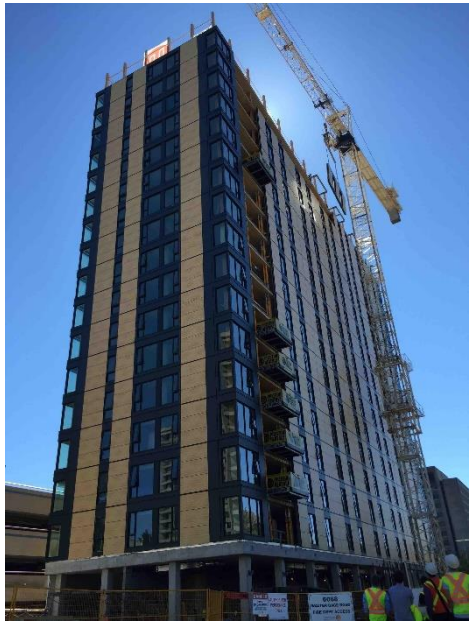
Noncombustible Protection Required

IV-A

IV-B

IV-C

IV-HT



Credit: LEVER Architecture

Credit: PATH Architecture

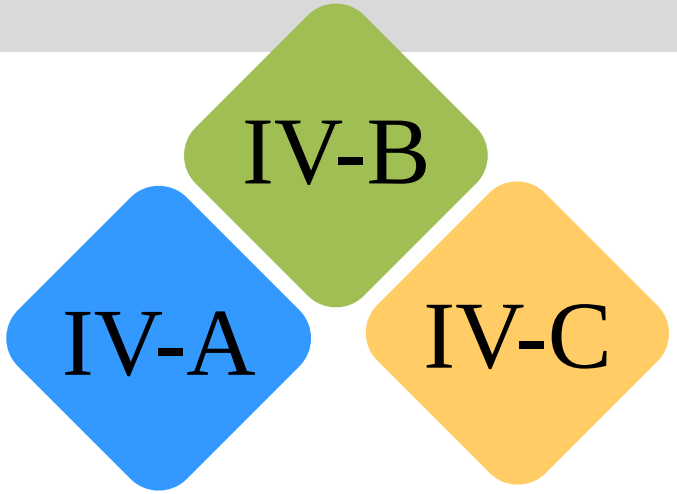
Photo: Blaine Brownell

Interior Wall Construction Recap

	IV-A	IV-B	IV-C	IV-HT
Fire Rating (bearing wall)	3 Hr	2 Hr	2 Hr	1 Hr or HT*
Construction – MT	Laminated construction 4” thick (CLT, NLT, etc) Solid wood construction min. 2 layers of 1” matched boards			
NC Protection	Per Interior Requirements			No
Noncombustible non-bearing wall	0 Hr			1 Hr
Wood Stud Wall	No			1 Hr

*IBC 2021 requires at least 1 Hr FRR for HT walls supporting 2 levels

Exterior Wall Construction Recap



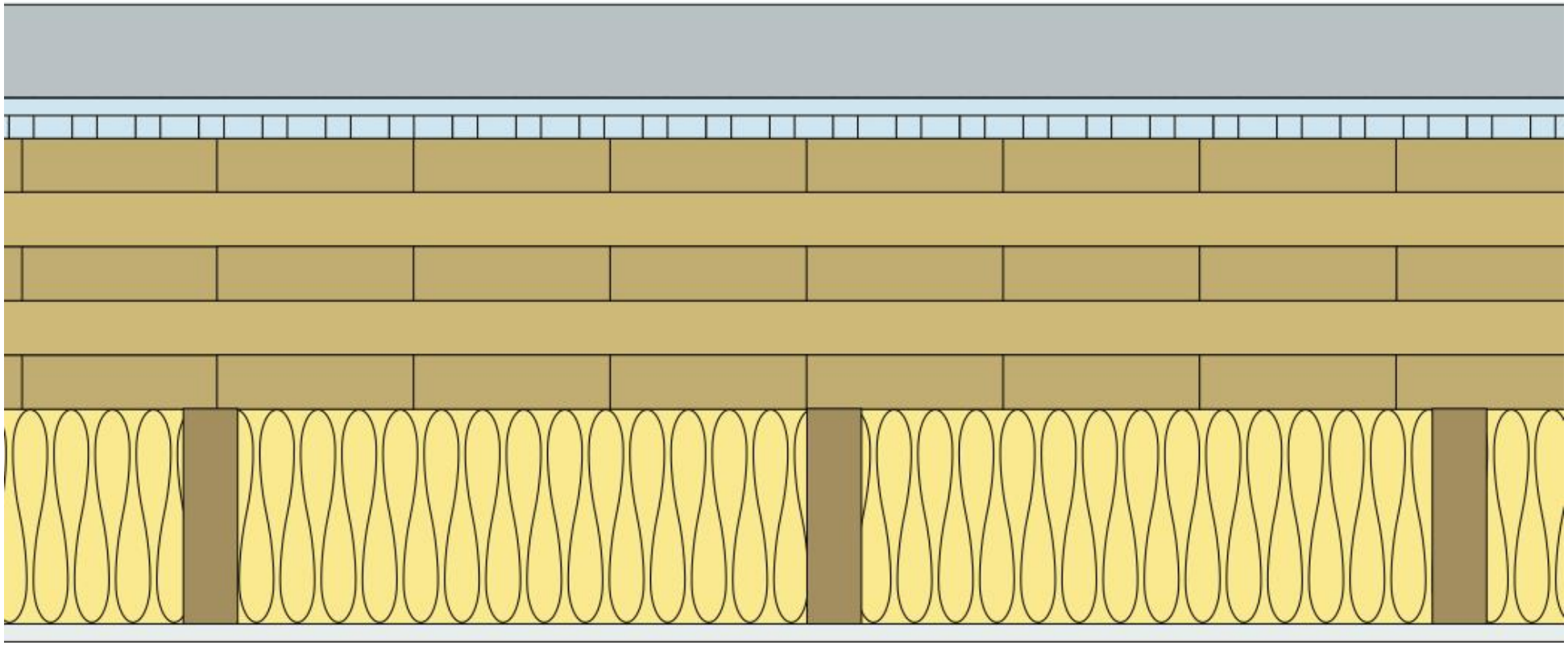
	IV-B	IV-A	IV-C	IV-HT (IBC 2021)	IV-HT (IBC 2018)
Fire Rating (bearing wall)	3 Hr	2 Hr	2 Hr	2 Hr	2Hr
Mass Timber	Mass Timber/CLT			4” min thick CLT*	6” Wall*
Exterior NC Protection	40 Min NC & No Exterior Combustible Coverings			FRT Sheathing, Gyp or other NC	
Interior NC Protection	Per Interior Requirements			Not Required	
Light Frame FRTW	No			Yes*	6” Wall*

*Changes in IBC 2015, 2018, and 2021 editions

Concealed Spaces in Type IV

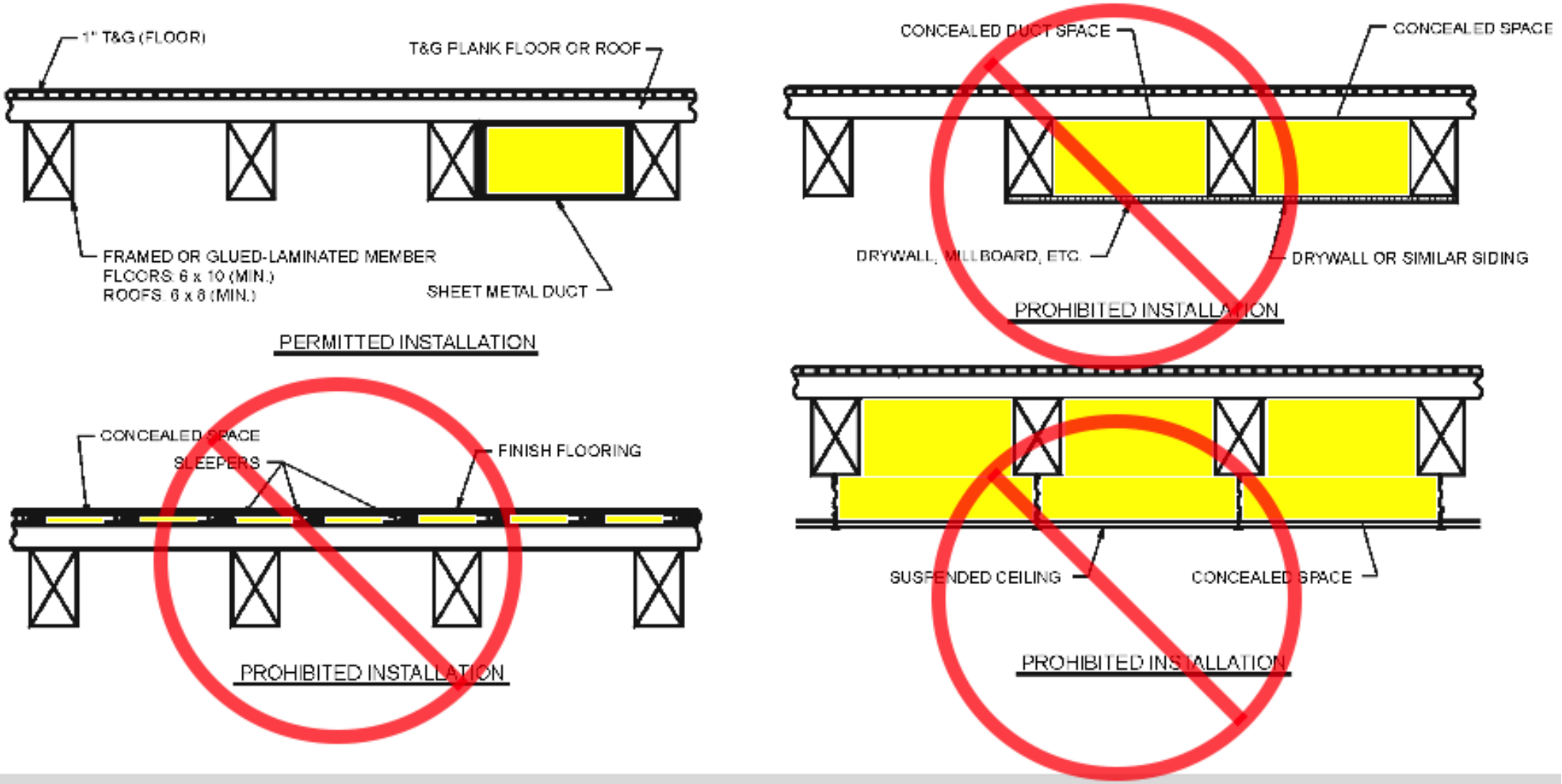
What if I have a dropped ceiling? Can I have a dropped ceiling?

- **Impact on FRR, NC placement, sprinkler requirements**



Concealed Spaces in Type IV

Previous Type IV (now IV-HT) provisions prohibited concealed spaces



Credit: IBC

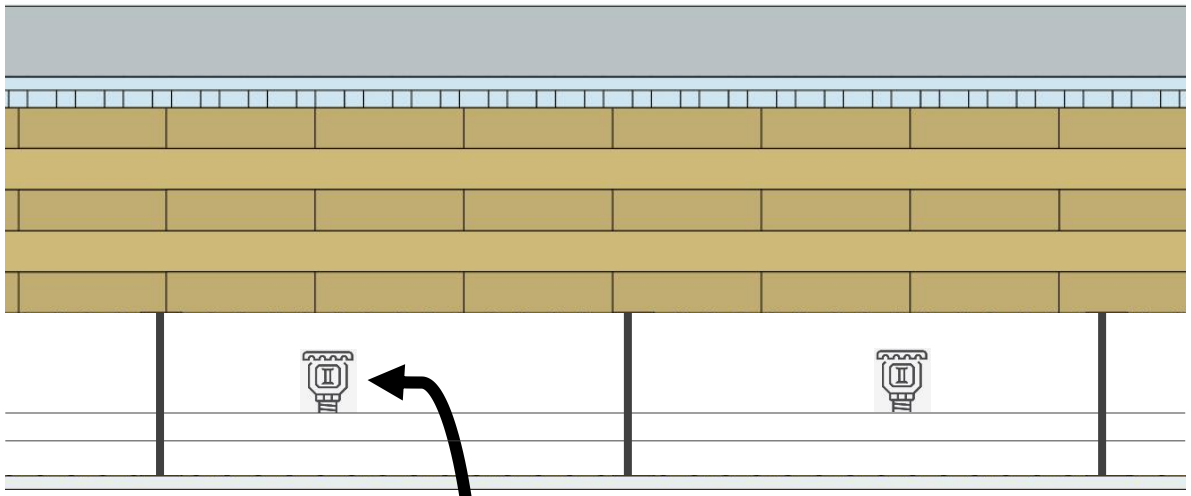
Concealed Spaces in Type IV

Type IV-HT (IBC 2021) permits concealed spaces where one of the following conditions exists:

1. The building is sprinklered throughout with an NFPA 13 Sprinkler and automatic sprinklers are provided in the concealed space.
2. The concealed space is completely filled with noncombustible insulation.
3. Surfaces within the concealed space are fully sheathed with not less than 5/8” Type X gypsum.

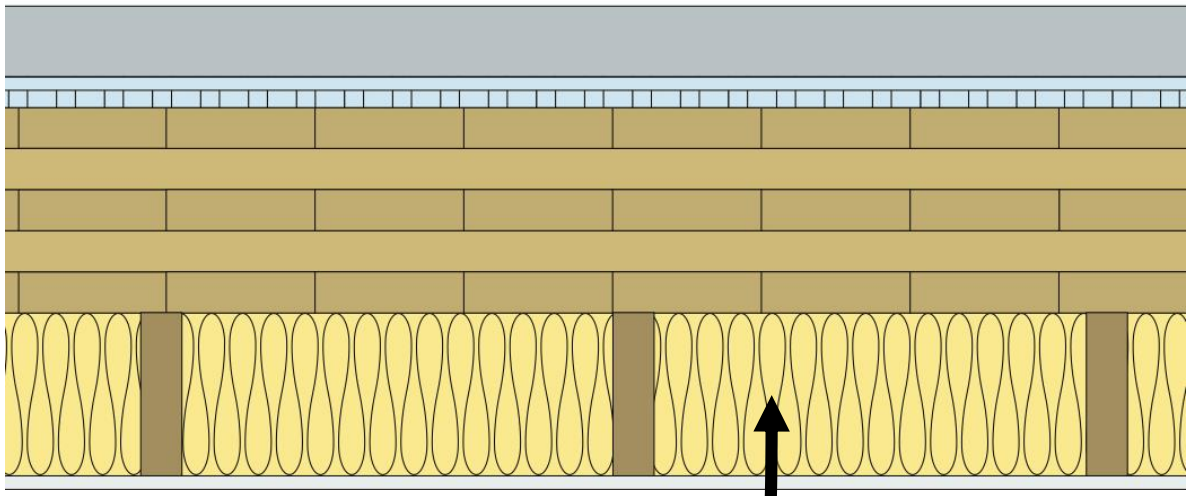
Concealed spaces within interior walls and partitions with a one hour or greater fire resistance rating complying Section 2304.11.2.2 do not require additional protection.

Concealed Spaces in Type IV-HT



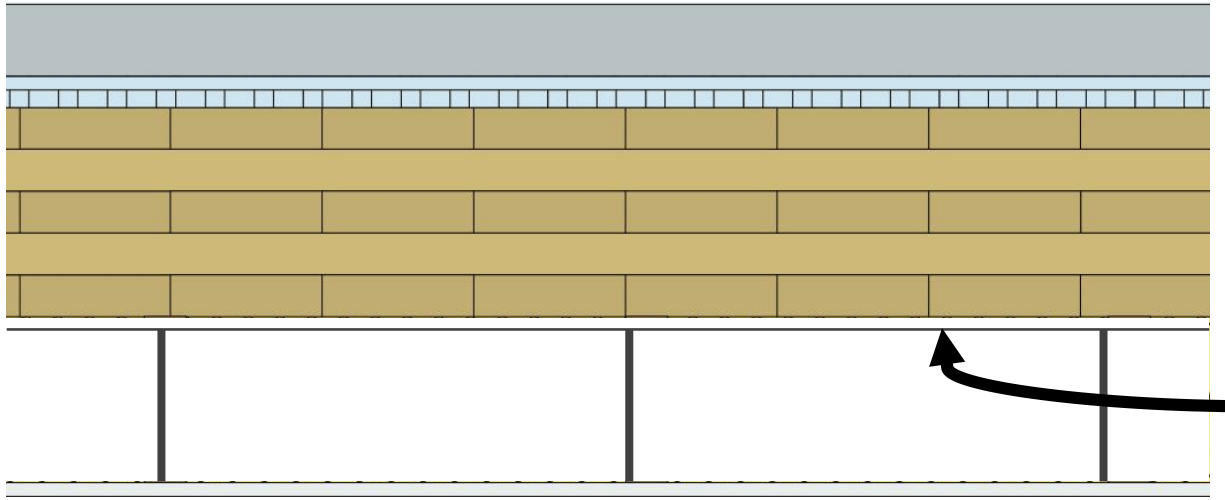
Option 1

Sprinklers in concealed spaces



Option 2

Noncombustible insulation



Option 3

5/8” Type X gypsum on all MT surfaces

Concealed Spaces in Type IV-A, IV-B, IV-C

New IV-HT concealed space provisions do not apply to IV-A, IV-B or IV-C

But, can still have concealed spaces in IV-A, IV-B, IV-C:

- **IV-A and IV-B:** Combustible construction forming concealed spaces protected with NC of 80 minutes (2 layers of 5/8” Type X Gypsum)
- **IV-C:** Combustible construction forming concealed spaces protected with NC of 40 minutes (1 layer of 5/8” Type X Gypsum)

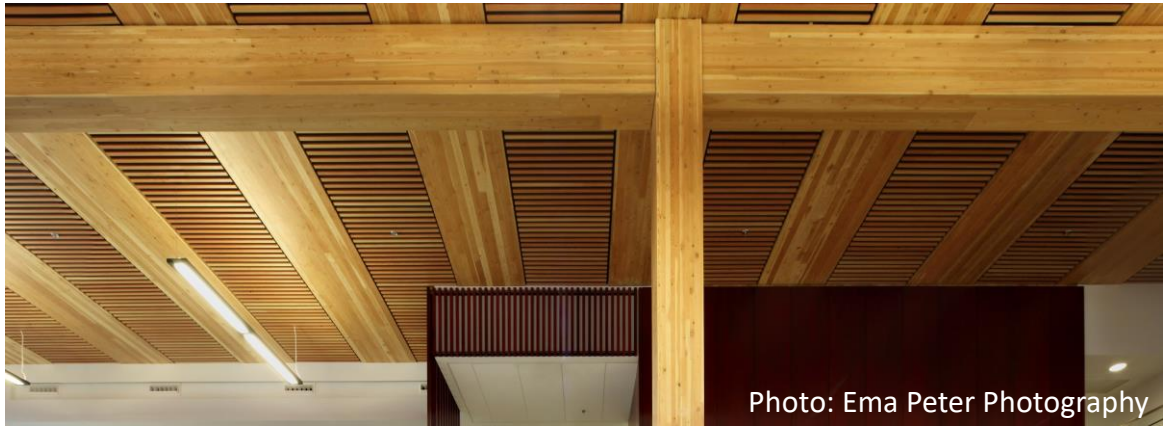


Photo: Ema Peter Photography

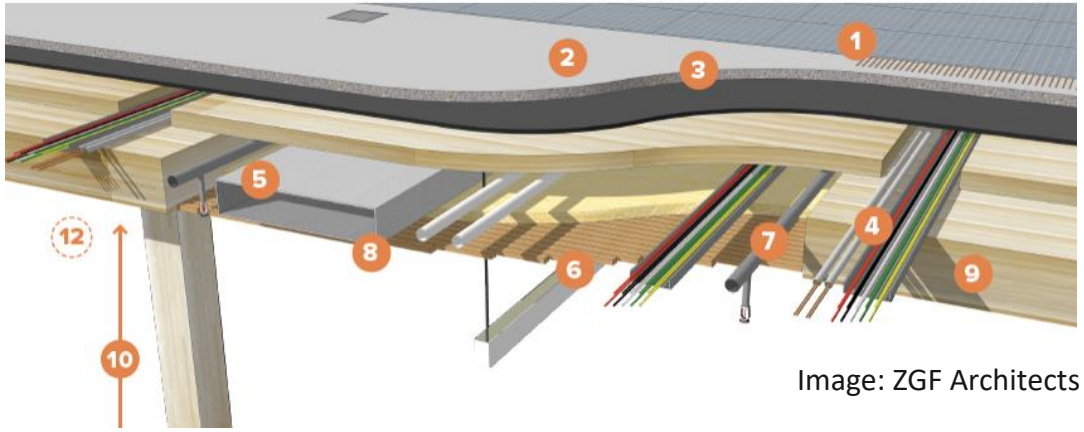


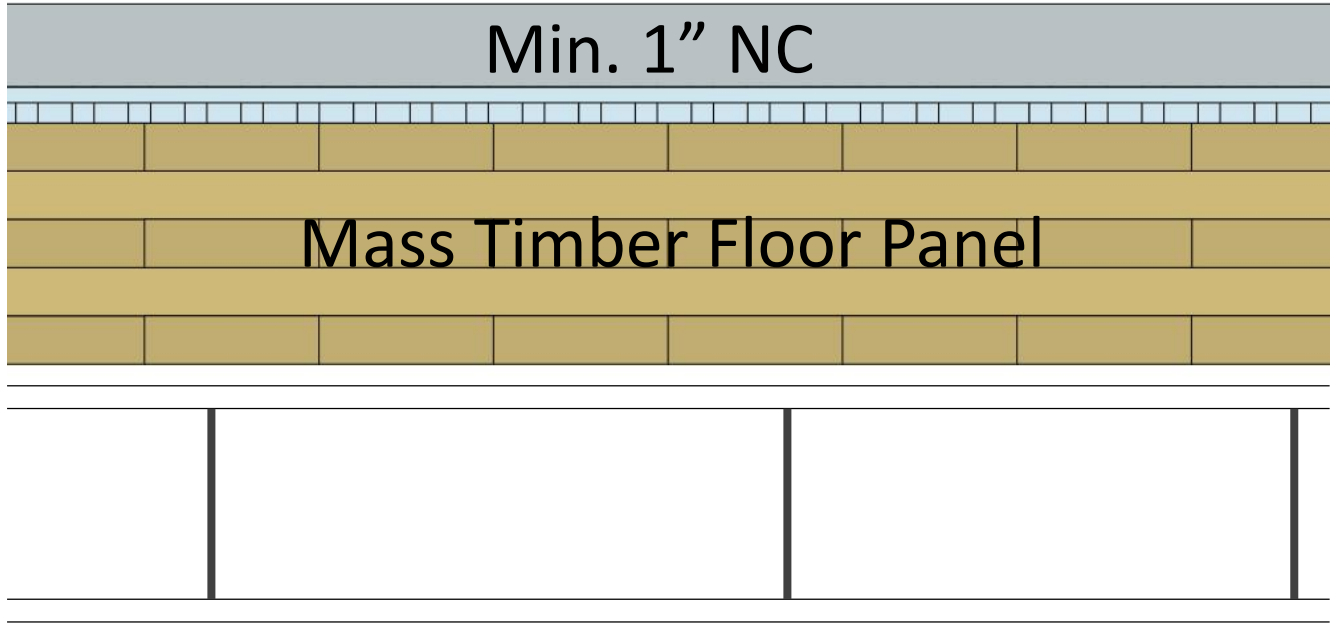
Image: ZGF Architects

Concealed Spaces in Type IV-A, IV-B

*Applicable to most locations. Limited exposed MT permitted in IV-B

2 layers 5/8” type X gypsum*

w/o dropped ceiling

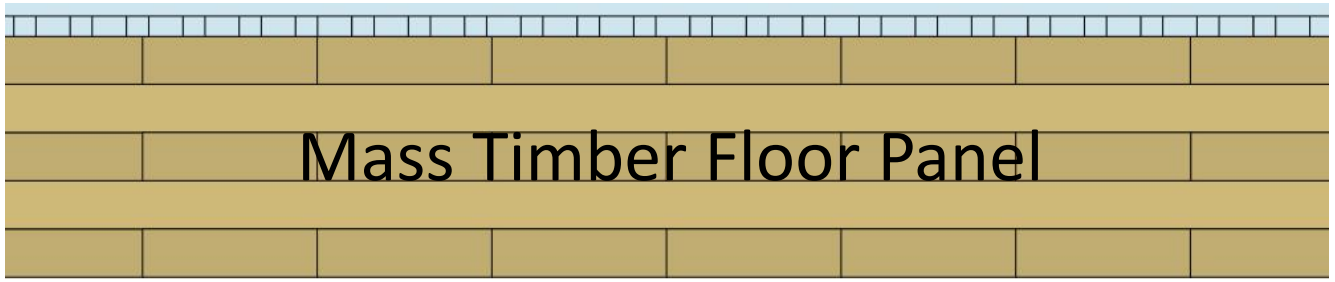


2 layers 5/8” type X gypsum

w/ dropped ceiling

Concealed Spaces in Type IV-C

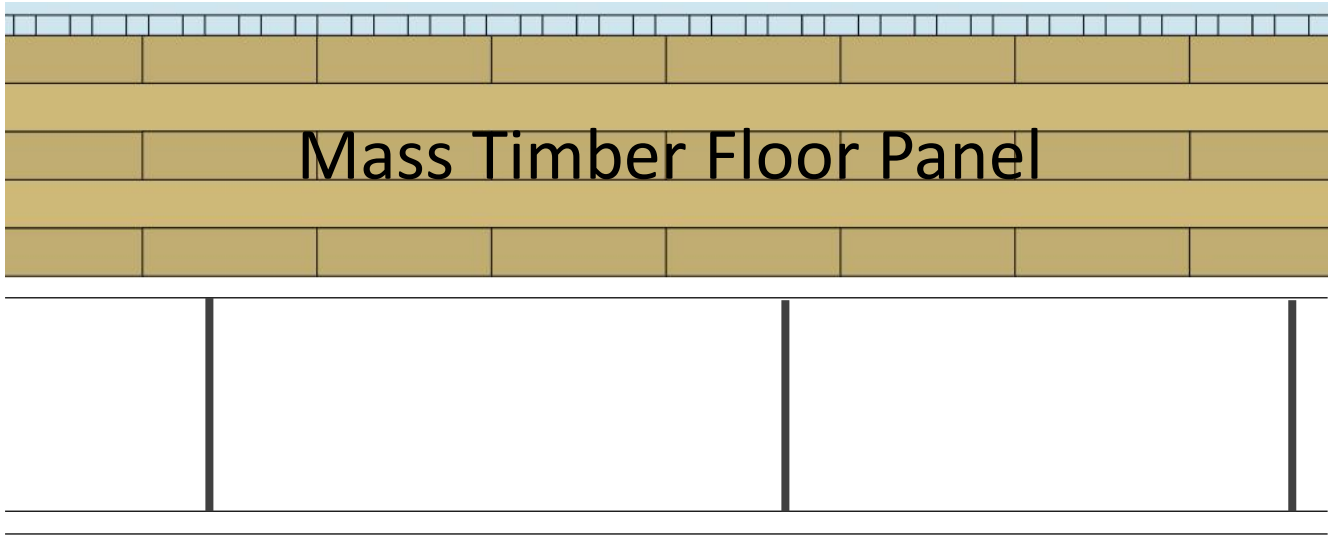
No NC req'd



No NC req'd

w/o dropped ceiling

No NC req'd



1 layer 5/8" type X gypsum

w/ dropped ceiling

Tall Wood Shaft Enclosures

- When can shaft enclosures be MT?
- What FRR requirements exist?
- If shaft enclosure is MT, is NC req'd?

Tall Wood Shaft Enclosures

	IV-A	IV-B	IV-C
Exit & Hoistway Enclosures	Up to 12 Stories or 180 ft: MT protected with 2 layers 5/8” type X gyp (if 2 HR req’d) or 3 layers 5/8” type X gyp (if 3 HR req’d) both sides Above 12 Stories or 180 ft: Noncombustible shafts (IBC 2021 602.4)	NC or MT protected with 2 layers 5/8” type X gyp (IBC 2021 602.4.2.6) both sides	NC or MT protected with 1 layer 5/8” type X gyp (IBC 602.4.3.6) both sides
E&H Enclosures FRR	2 HR (not less than FRR of floor assembly penetrated, IBC 713.4)		

DOES TALL WOOD = HIGH RISE?

Photo: Ema Peter

Mid-Rise vs. High-Rise

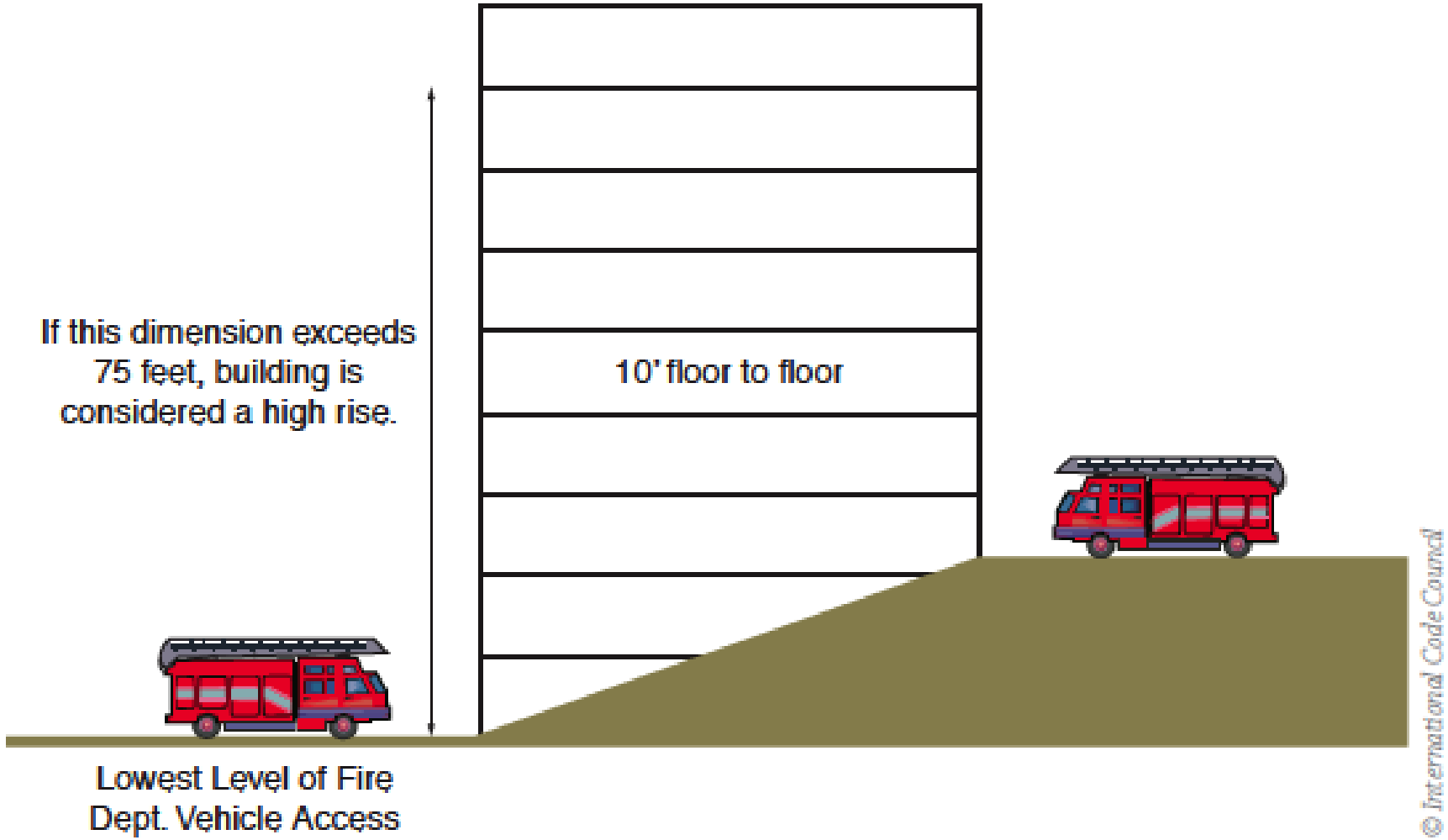


FIGURE 6-6 Determination of high-rise building

Sprinklers in High Rises

- **Two Water Mains Required if:**
  - Building Height Exceeds 420 ft, or
  - **Type IV-A and IV-B buildings that exceed 120 ft in height**

Photo: Michael Green Architecture

ADDRESSING CLT CHAR FALL OFF

CLT Fire Performance – Char Fall Off

CLT char fall off or heat induced delamination occurs when laminations (or pieces thereof) fall off the underside of a CLT panel under extended fire conditions.

Photo: Urban One

Photo: ARUP

CLT Fire Performance – Fire Re-Growth

In tall buildings, preventing fire re-growth is key.
Fire re-growth is a phenomenon in which the heat-release rate of a fire intensifies following a decay phase. Fire re-growth can be initiated when delamination occurs, as this exposes un-charred wood surfaces, thereby resulting in an influx of fuel available for consumption by the fire.


Photo: Urban One


Photo: ARUP

CLT Fire Performance – Char Fall Off

Facts about CLT char fall off:

- **Only an item to consider in tall buildings. Important to avoid in high-rise construction where required performance is containment of fire within compartment of origin with no sprinkler or fire service suppression**
- **Not applicable when discussing mid-rise mass timber (or any building under types II, III, IV-HT or V)**
- **Largely a function of adhesive performance under high temps**
- **Has been addressed in PRG 320-18 (required for all CLT under 2021 IBC, not just tall wood)**

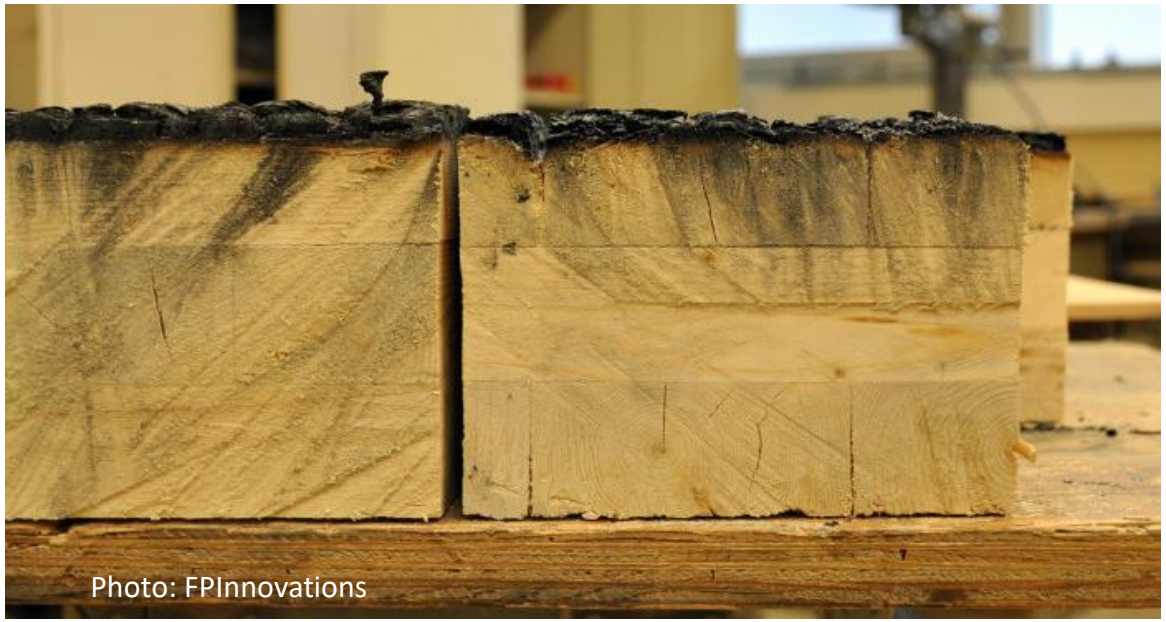
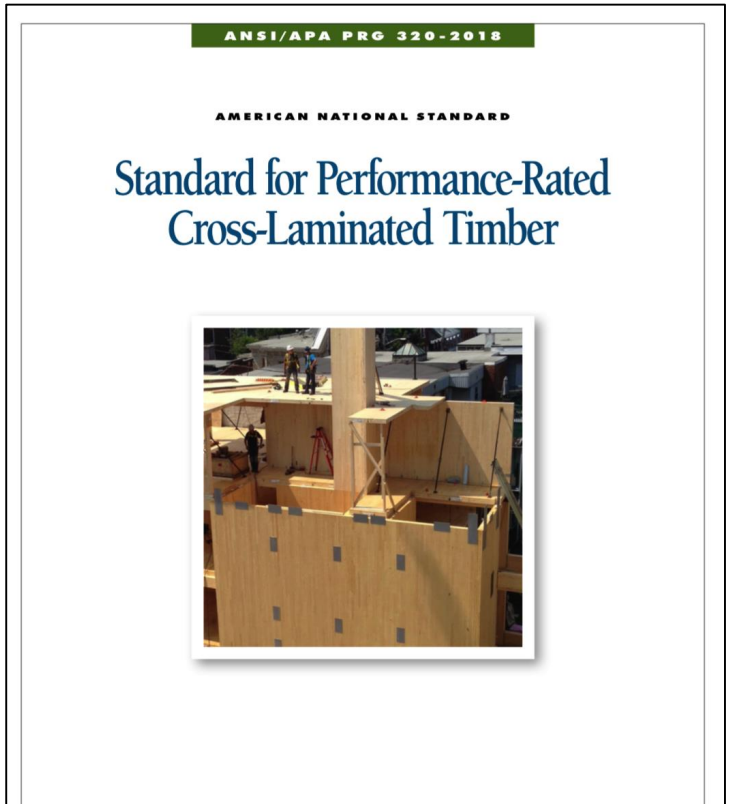


Photo: FPInnovations

CLT Fire Performance – PRG 320

2021 IBC Section 602.4 added:

Cross-laminated timber shall be labeled as conforming to PRG 320 - 18 as referenced in Section 2303.1.4.



CLT Fire Performance – PRG 320

PRG 320 is manufacturing & performance standard for CLT.
2018 edition (referenced in 2021 IBC) added new elevated temperature adhesive performance requirements validated by full-scale and medium-scale qualification testing to ensure CLT does not exhibit fire re-growth

When designing tall wood – specify CLT per PRG 320-18 (req'd in IBC 2021 for all CLT)

ANNEX B. PRACTICE FOR EVALUATING ELEVATED TEMPERATURE PERFORMANCE OF ADHESIVES USED IN CROSS-LAMINATED TIMBER (MANDATORY)

CONNECTIONS IN TALL WOOD

Photo: Structurlam

Connection Fire Protection

In Construction Types IV-A, IV-B & IV-C, building elements are required to be FRR as specified in IBC Tables 601 and 602. Connections between these building elements must be able to maintain FRR no less than that required of the connected members.

Photo: MyTiCon

16.3 Wood Connections

Wood connections, including connectors, fasteners, and portions of wood members included in the connection design, shall be protected from fire exposure for the required fire resistance time. Protection shall be provided by wood, fire-rated gypsum board, other approved materials, or a combination thereof.

Source: NDS

Connection Fire Protection

Many ways to demonstrate connection fire protection: calculations, prescriptive NC, test results, others as approved by AHJ


Photo: John Stamets


Photo: Josh Partee

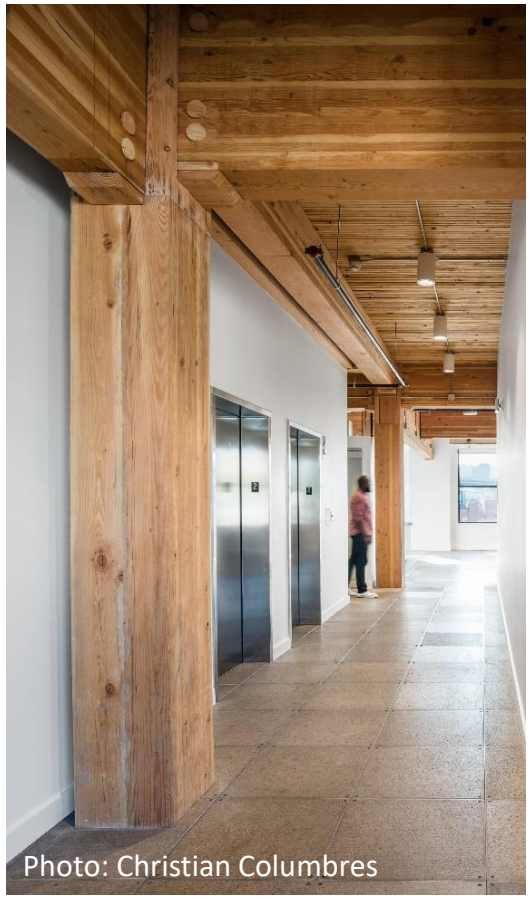


Photo: Christian Columbres

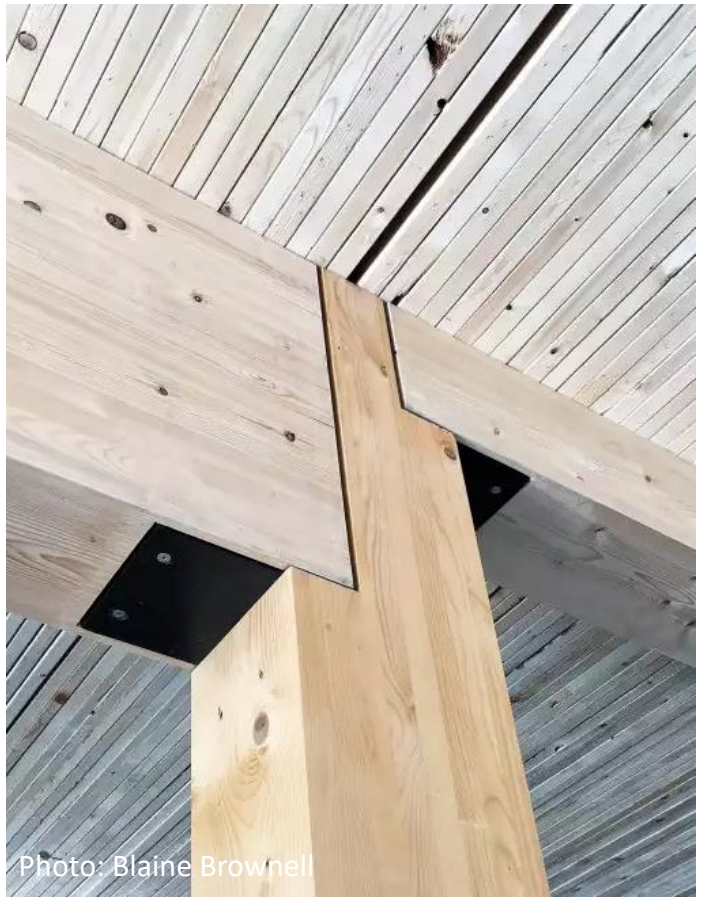


Photo: Blaine Brownell

Connection Fire Protection

2017 Glulam Beam to Column Connection Fire Tests under standard ASTM E119 time-temperature exposure

Connection Fire Protection

Fire Test Results

Test	Beam	Connector	Applied Load	FRR
1	8.75” x 18” (222mm x 457mm)	1 x Ricon S VS 290x80	3,905lbs (17.4kN)	1hr
2	10.75” x 24” (273mm x 610mm)	Staggered double Ricon S VS 200x80	16,620lbs (73.9kN)	1.5hrs
3	10.75” x 24” (273mm x 610mm)	1 x Megant 430	16,620lbs (73.9kN)	1.5hrs

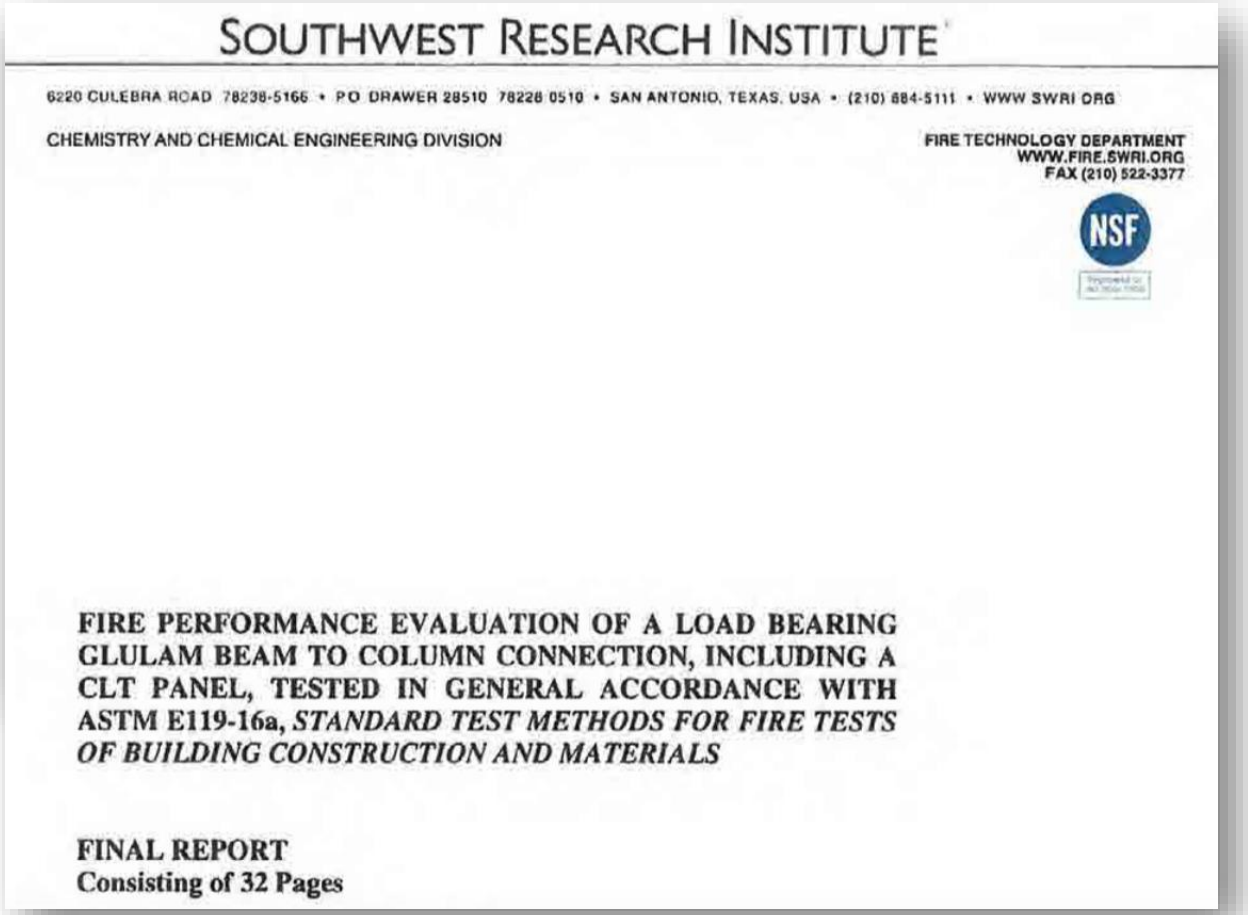
Connection Fire Protection


Softwood Lumber Board

Glulam Connection Fire Test

Summary Report

Issue | June 5, 2017


SOUTHWEST RESEARCH INSTITUTE

6220 CULEBRA ROAD 78238-5166 • P.O. DRAWER 28510 78228-0510 • SAN ANTONIO, TEXAS, USA • (210) 684-5111 • WWW.SWRI.ORG

CHEMISTRY AND CHEMICAL ENGINEERING DIVISION

FIRE TECHNOLOGY DEPARTMENT
WWW.FIRE.SWRI.ORG
FAX (210) 522-3377

NSF

FIRE PERFORMANCE EVALUATION OF A LOAD BEARING GLULAM BEAM TO COLUMN CONNECTION, INCLUDING A CLT PANEL, TESTED IN GENERAL ACCORDANCE WITH ASTM E119-16a, *STANDARD TEST METHODS FOR FIRE TESTS OF BUILDING CONSTRUCTION AND MATERIALS*

FINAL REPORT
Consisting of 32 Pages

Full Report Available at:

https://www.thinkwood.com/wp-content/uploads/2018/01/reThink-Wood-Arup-SLB-Connection-Fire-Testing-Summary-web.pdf

PENETRATIONS IN TALL WOOD

Photo: Alex Schreyer

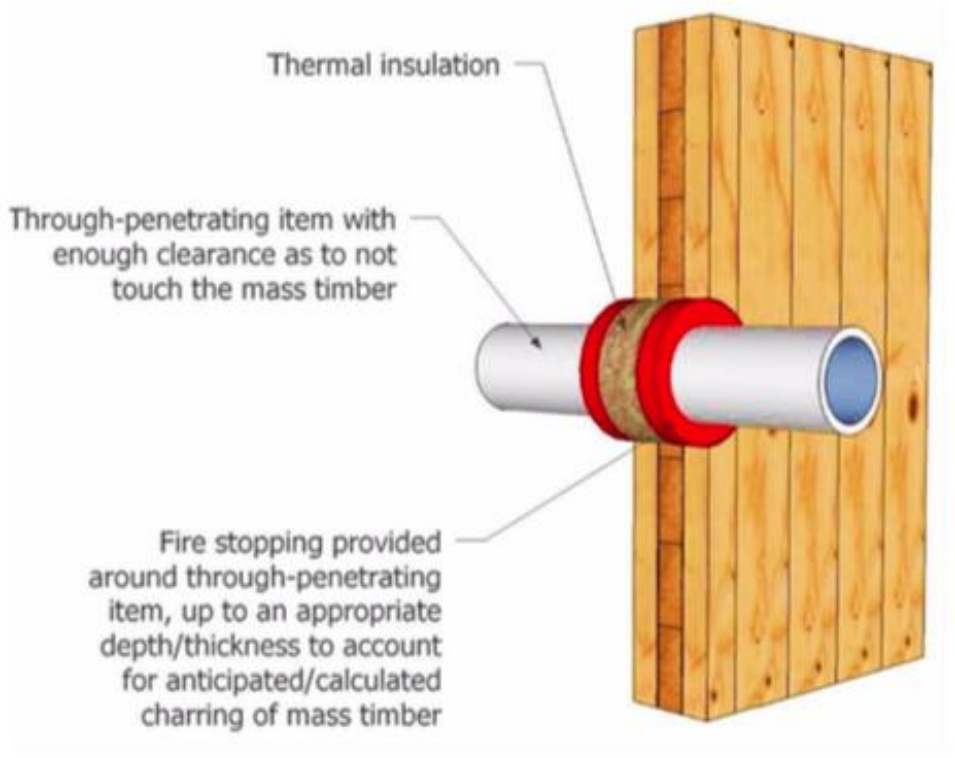
Penetration Fire Protection

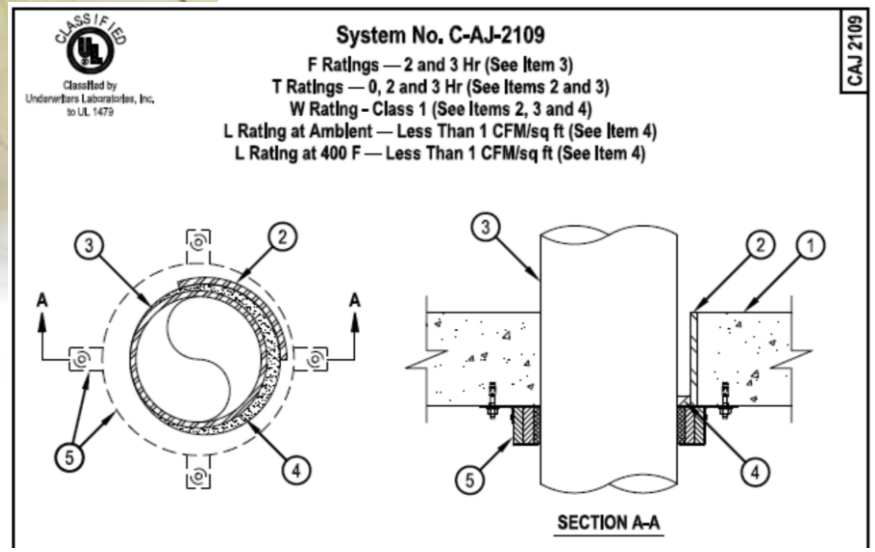
Although not a new code requirement or specific to tall wood, more testing & information is becoming available on firestopping of penetrations through MT assemblies

Photos: AWC/FPInnovations

Penetration Fire Protection

Most firestopping systems include combination of fire safing (eg. noncombustible materials such as mineral wool insulation) plus fire caulk





Photos: AWC/FPInnovations/Hilti

Penetration Fire Protection

Firestop systems tests on Mass Timber
Contact WoodWorks for information

SOUTHWEST RESEARCH INSTITUTE®

6220 CULEBRA ROAD 78238-5166 • P.O. DRAWER 28510 78228-0510 • SAN ANTONIO, TEXAS, USA • (210) 684-5111 • WWW.SWRI.ORG

CHEMISTRY AND CHEMICAL ENGINEERING DIVISION

FIRE TECHNOLOGY DEPARTMENT
WWW.FIRE.SWRI.ORG
FAX (210) 522-3377

FIRE RESISTANCE PERFORMANCE EVALUATION OF A PENETRATION FIRESTOP SYSTEM TESTED IN ACCORDANCE WITH ASTM E814-13A, *STANDARD TEST METHOD FOR FIRE TESTS OF PENETRATION FIRESTOP SYSTEMS*

FINAL REPORT
Consisting of 18 Pages

SwRI® Project No. 01.21428.01.001a
Test Date: September 30, 2015
Report Date: October 22, 2015

Prepared for:

American Wood Council
222 Catoctin Circle SE
Leesburg, VA 20175

WCTE 2018
2018 World Conference on Timber Engineering
August 20 - 23, 2018 | Seoul, Republic of Korea

FIRE PERFORMANCE OF FIRESTOPS, PENETRATIONS, AND FIRE DOORS IN MASS TIMBER ASSEMBLIES

Lindsay Ranger [1], Christian Dagenais [1], Conroy Lum[1], Tony Thomas[1]

ABSTRACT: Integrity and continuity must be maintained for fire separations required to provide fi
prevent passage of hot gases or increased temperature on the unexposed side. Vulnerable locations, whe
are introduced into mass timber systems, are susceptible to fire spread. Service and closure penetrat
timber fire separation have been investigated. Many of the fire stop systems were able to achieve 1-½
accordance with CAN/ULC-S115, which would be required for 2-hr fire resistance rated assemblies, su
tall wood buildings. Construction details are outlined which ensure adequate fire performance of these p

KEYWORDS: Firestop, through-penetrations, fire rated door, mass timber, cross-laminated tim
buildings, fire resistance

1 INTRODUCTION

Many tall wood buildings using mass timber are planned or are currently being designed for construction around the world. A few have been built in Canada, including an 18 storey cross-laminated timber (CLT) and glulam building in British Columbia. The prescriptive requirements in the National Building Code of Canada (NBCC) [1] do not (yet) permit the construction of wood buildings taller than six stories, however an alternative

construction, as well as in several alter
building designs.

Although the general fire performance
well documented, there are still sever
warrant further investigation to ensure
safety levels are met and a number
available for designers to use. Generating
generic assemblies will reduce the need f
completed on an individual construction

GHL CONSULTANTS LTD

409 GRANVILLE STREET, SUITE 950
VANCOUVER, BC V6C 1T2 CANADA

P 604 689 4449
F 604 689 4419
www.ghl.ca
Holder of AIBC Certificate of Practice

FIRESTOPPING TEST WITNESS REPORT

for

NORDIC STRUCTURES

Penetration Fire Protection

Inventory of Fire Tested Penetrations in MT Assemblies

WoodWorks™ WOOD PRODUCTS COUNCIL

Table 3: North American Fire Tests of Penetrations and Fire Stops in CLT Assemblies

CLT Panel	Exposed Side Protection	Penetrating Item	Penetrant Centered or Offset in Hole	Firestopping System Description	F Rating	T Rating	Stated Test Protocal	Source	Testing Lab
3-ply (78mm 3.07")	None	1.5" diameter data cable bunch	Centered	3.5 in diameter hole. Mineral wool was installed in the 1in. annular space around the data cables to a total depth of approximately 2 – 5/64 in. The remaining 1in. annular space from the top of the mineral wool to the top of the floor assembly was filled with Hilti FS-One Max caulking.	1 hour	0.5 hour	CANULC S115	26	Intertek March 30, 2016
3-ply (78mm 3.07")	None	2" copper pipe	Centered	4.375 in diameter hole. Pipe wrap was installed around the copper pipe to a total depth of approximately 2 – 5/64 in. The remaining 1in. annular space starting at the top of the mineral wool to the top of the floor assembly was filled with Hilti FS-One Max caulking.	1 hour	N.A.	CANULC S115	26	Intertek March 30, 2016
3-ply (78mm 3.07")	None	2.5" sched. 40 pipe	Centered	4.92 in diameter hole. Pipe wrap was installed around the schedule 40 pipe to a total depth of approximately 2 – 5/64 in. The remaining 1in. annular space starting at the top of the pipe wrap to the top of the floor assembly was filled with Hilti FS-One Max caulking.	1 hour	N.A.	CANULC S115	26	Intertek March 30, 2016
3-ply (78mm 3.07")	None	6" cast iron pipe	Centered	8.35 in diameter hole. Mineral wool was installed in the 1in. annular space around the cast iron pipe to a total depth of approximately 2 – 5/64 in. The remaining 1in. annular space starting at the top of the pipe wrap to the top of the floor assembly was filled with Hilti FS-One Max caulking.	1 hour	N.A.	CANULC S115	26	Intertek March 30, 2016
3-ply (78mm 3.07")	None	Hilti 6 in drop in device. System No.: F-B-2049	Centered	9.01" diameter hole. Mineral wool was installed in the 1 – 1/4in. annular space around the drop-in device to a total depth of approximately 1 – 7/64in and the remaining 1in. annular space from the top of the mineral wool to the top edge of the 9 – 1/64in. hole in the CLT was filled with Hilti FS-One Max caulking.	1 hour	0.75 hour	CANULC S115	26	Intertek March 30, 2016
5-ply CLT (131mm 5.16")	None	1.5" diameter data cable bunch	Centered	3.5" diameter hole. Mineral wool was installed in the 1in. annular space around the data cables to a total depth of approximately 4 – 5/32 in. The remaining 1in. annular space from the top of the mineral wool to the top of the floor assembly was filled with Hilti FS-One Max caulking.	2 hours	1.5 hours	CANULC S115	26	Intertek March 30, 2016
5-ply CLT (131mm 5.16")	None	2" copper pipe	Centered	4.375 in diameter hole. Pipe wrap was installed around the copper pipe to a total depth of approximately 4 – 5/32 in. The remaining 1in. annular space starting at the top of the mineral wool to the top of the floor assembly was filled with Hilti FS-One Max caulking.	2 hours	N.A.	CANULC S115	26	Intertek March 30, 2016
5-ply CLT (131mm 5.16")	None	2.5" sched. 40 pipe	Centered	4.92 in diameter hole. Pipe wrap was installed around the schedule 40 pipe to a total depth of approximately 4 – 5/32 in. The remaining 1in. annular space starting at the top of the pipe wrap to the top of the floor assembly was filled with Hilti FS-One Max caulking.	2 hours	0.5 hour	CANULC S115	26	Intertek March 30, 2016
5-ply CLT (131mm 5.16")	None	6" cast iron pipe	Centered	8.35 in diameter hole. Mineral wool was installed in the 1in. annular space around the cast iron pipe to a total depth of approximately 4 – 5/32 in. The remaining 1in. annular space starting at the top of the pipe wrap to the top of the floor assembly was filled with Hilti FS-One Max caulking.	2 hours	N.A.	CANULC S115	26	Intertek March 30, 2016
5-ply CLT (131mm 5.16")	None	Hilti 6 in drop in device. System No.: F-B-2049	Centered	9.01" diameter hole. Mineral wool was installed in the 1 – 1/4in. annular space around the drop-in device to a total depth of approximately 1 – 7/64in and the remaining 1in. annular space from the top of the mineral wool to the top edge of the 9 – 1/64in. hole in the CLT was filled with Hilti FS-One Max caulking.	2 hours	1.5 hours	CANULC S115	26	Intertek March 30, 2016
5-ply (175mm 6.875")	None	1" nominal PVC pipe	Centered	4.21 in diameter with a 3/4 in plywood reducer flush with the top of the slab reducing the opening to 2.28 in. Two wraps of Hilti CP 648-E W4 5/1-3/4" Firestop wrap strip at two locations with a 30 gauge steel sleeve which extended from the top of the slab to 1 in below the slab. The first location was with the bottom of the wrap strip flush with the bottom of the steel sleeve and the second was with the bottom of the wrap strip 3 in. from the bottom of the slab. The void between the steel sleeve and the CLT and between the steel sleeve and pipe at the top was filled with Roxul Safe mineral wool leaving a 3/4 in deep void at the top of the assembly. Hilti FS-One Max Intumescent Firestop Sealant was applied to a depth of 3/4 in on the top of the assembly between the plywood and steel sleeve as well as the steel sleeve and pipe.	2 hours	2 hours	ASTM E814	24	QAI Laboratories March 3, 2017

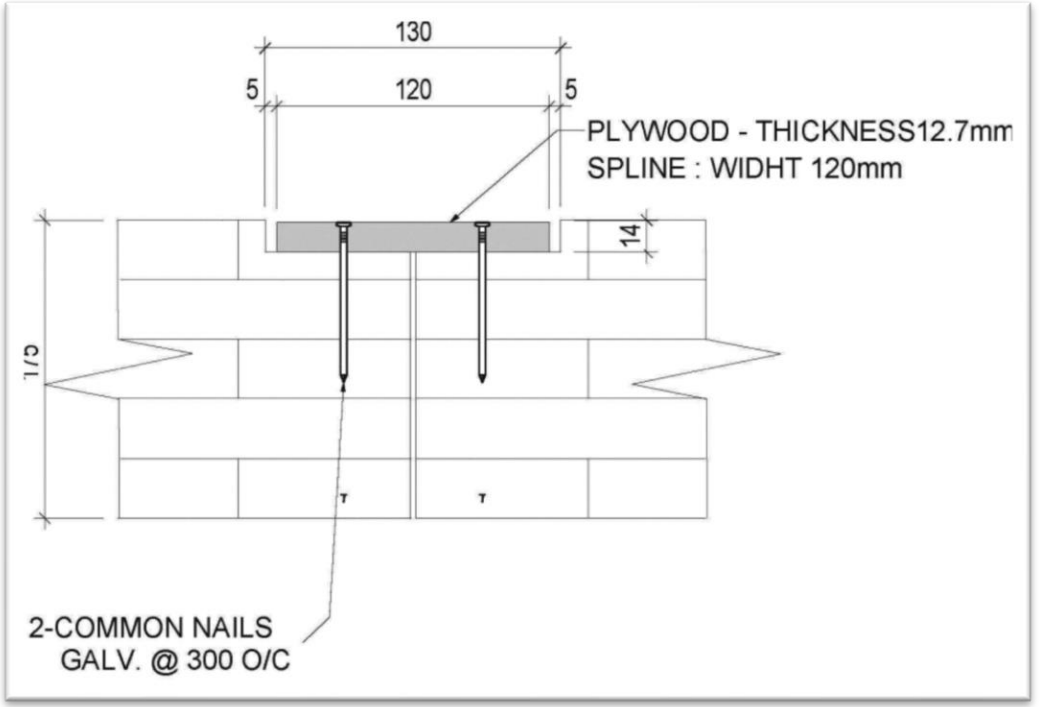
SEALANTS AT MT PANEL EDGES

Photos: ARUP

Sealants at MT Panel Edges

703.9 Sealing of adjacent mass timber elements. In buildings of Type IVA, IVB, and IVC construction, sealant or adhesive shall be provided to resist the passage of air in the following locations:

1. At abutting edges and intersections of mass timber building elements required to be fire resistance-rated
2. At abutting intersections of mass timber building elements and building elements of other materials where both are required to be fire resistance-rated.



Sealants at MT Panel Edges

Sealants shall meet the requirements of ASTM C920 (elastomeric joint sealants). Adhesives shall meet the requirements of ASTM D3498 (gap filling construction adhesives, i.e. not fire caulk).

Exception: Sealants or adhesives need not be provided where they are not a required component of a fire resistance- rated assembly.


Photo: NRCAN


Photo: Charles Judd


Photo: ARUP

Sealants at MT Panel Edges

Several MT fire tested assemblies have successfully been completed w/o adhesives/sealants at abutting panel edges

2021 IBC will require periodic special inspections of adhesive/sealant installation (when required to be installed)


Photo: NRCAN


Photo: Fast + Epp


Photo: ARUP

Occupancy Separation

Protection of MT used for occupancy separation

Addition to IBC 508.4.4.1 requires:
Mass timber elements serving as fire barriers or horizontal assemblies to separate occupancies in Type IV-B or IV-C construction shall be separated from the interior of the building with a minimum of ½” gypsum board or a noncombustible equivalent.

Photo: MIT | John Klein

Incidental Use Separation

Protection of MT used for incidental use separation

New section 509.4.1.1 requires:
Where Table 509 specifies a fire- resistance-rated separation, mass timber elements serving as fire barriers or a horizontal assembly in Type IV-B or IV-C construction shall be separated from the interior of the incidental use with a minimum of ½” gypsum board or a noncombustible equivalent.

Photo: MIT | John Klein

Fire Safety During Construction

New code provisions in International Fire Code (IFC) address construction fire safety of tall wood buildings

3308.4 Fire safety requirements for buildings of Types IV-A, IV-B, and IV-C construction. Buildings of Types IV-A, IV-B, and IV-C construction designed to be greater than six stories above grade plane shall meet the following requirements during construction unless otherwise approved by the fire code official.

1. Standpipes shall be provided in accordance with Section 3313.
2. A water supply for fire department operations, as approved by the fire chief.

Photo: Structurlam

Fire Safety During Construction

IFC 3313 Standpipe Requirements

SECTION 3313
STANDPIPES

3313.1 Where required.

In buildings required to have standpipes by Section 905.3.1, not less than one standpipe shall be provided for use during construction. Such standpipes shall be installed prior to construction exceeding 40 feet (12 192 mm) in height above the lowest level of fire department vehicle access. Such standpipe shall be provided with fire department hose connections at accessible locations adjacent to usable stairways. Such standpipes shall be extended as construction progresses to within one floor of the highest point of construction having secured decking or flooring.

3313.2 Buildings being demolished.

Where a building is being demolished and a standpipe is existing within such a building, such standpipe shall be maintained in an operable condition so as to be available for use by the fire department. Such standpipe shall be demolished with the building but shall not be demolished more than one floor below the floor being demolished.

3313.3 Detailed requirements.

Standpipes shall be installed in accordance with the provisions of Section 905.

Exception: Standpipes shall be either temporary or permanent in nature, and with or without a water supply, provided that such standpipes comply with the requirements of Section 905 as to capacity, outlets and materials.

Credit: IFC

Fire Safety During Construction

IFC 3308.4 Cont'd

3. Where building construction exceeds six stories above grade plane, at least one layer of noncombustible protection where required by Section 602.4 of the International Building Code shall be installed on all building elements more than 4 floor levels, including mezzanines, below active mass timber construction before erecting additional floor levels.
4. Where building construction exceeds six stories above grade plane required exterior wall coverings shall be installed on all floor levels more than 4 floor levels, including mezzanines, below active mass timber construction before erecting additional floor level.

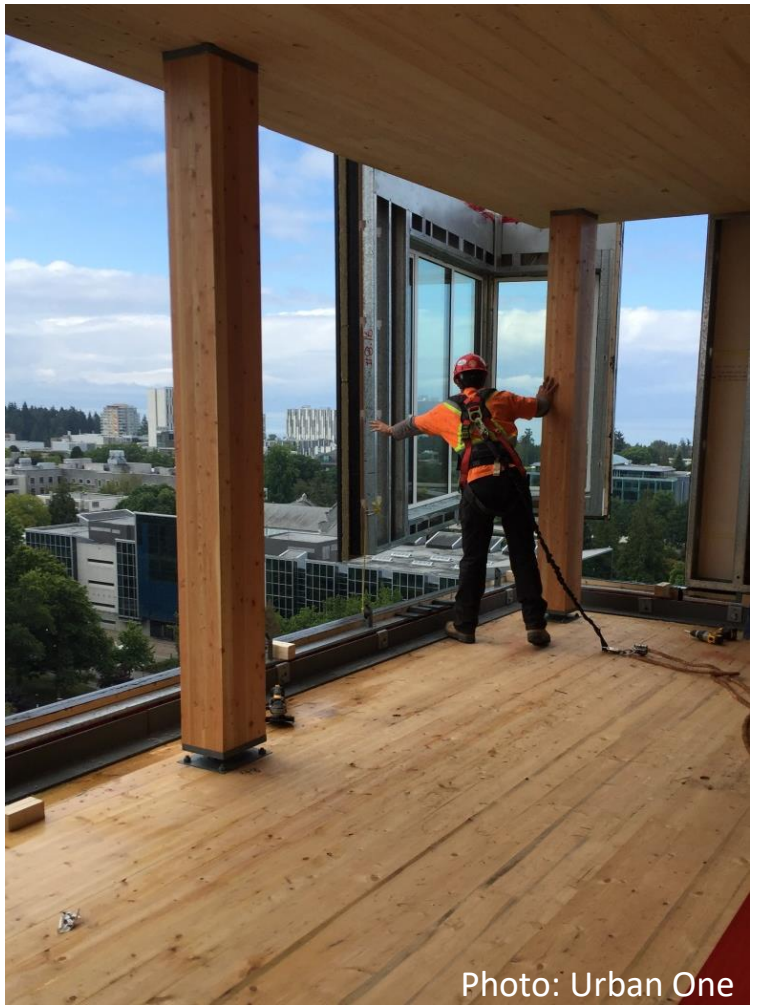


Photo: Urban One

Exception: Shafts and vertical exit enclosures

Fire Safety During Construction

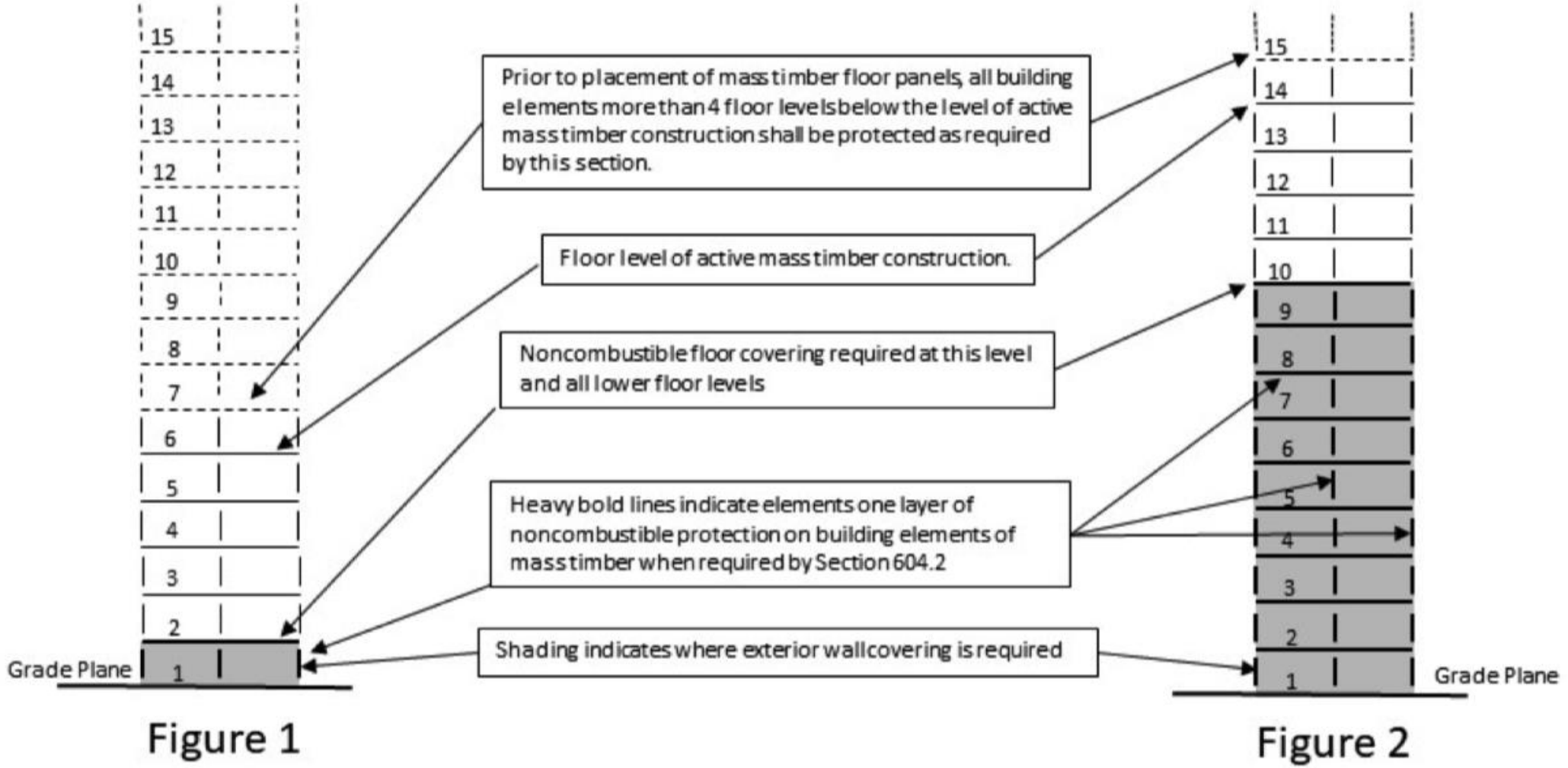


Figure 1

Figure 2

Examples of Protection During Construction For Mass Timber Buildings Greater Than 6 Stories Above Grade Plane

Credit: ICC

QUESTIONS?

This concludes The American Institute of Architects Continuing Education Systems Course

Speaker name

Speaker organization

Speaker email address

Copyright Materials